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EUROPEAN OVERSIGHT TRIP

REPORT

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC, June 20, 1985.

To All Members, Committee on Science and Technology:

There is transmitted herewith a report on an oversight review of European science and technology activities conducted during the period May 24 through June 3, 1985.

The oversight review of key energy, space, aeronautics, transportation, and science facilities and briefings was designed to provide the Members of the Committee with an insight into European activities in those areas falling within the jurisdiction of the Committee. In addition, the discussions with senior officials during the in-country briefings held in each country provided invaluable insight into the plans and attitudes of our European allies.

I commend the report to your attention.

Sincerely,

DON FUQUA, *Chairman.*

LETTER OF SUBMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC, June 1985.

Hon. DON FUQUA,
Chairman, Committee on Science and Technology,
U.S. House of Representatives.

DEAR MR. CHAIRMAN: I am forwarding you this report on the Committee's European Oversight trip conducted between May 24 and June 3, 1985. The report includes the highlights of the facility visits and the discussions with the U.S. and foreign officials and a report on each.

On your instructions, the Committee developed a plan to conduct a rigorous review of as many key energy, space, aeronautics and transportation facilities as well as key science policy discussions as time permitted. The schedule and oversight activities were designed to give Members and staff a firsthand opportunity to assess the status, performance and plans of our European allies in developing energy technologies, space research, transportation enhancements, aviation growth and science policy which will complement and or compete with the United States interests.

In my opinion, the Committee staff has provided excellent professional support to this oversight activity as evidenced in the attached report.

Sincerely,

HAROLD P. HANSON, *Executive Director.*

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NOTE.—The Committee also intended to travel to Budapest, Hungary to meet with senior government officials to discuss science policy and R&D issues. These meetings will be rescheduled at a later time.

INTRODUCTION

The Committee on Science and Technology has as its oversight jurisdiction all civilian research and development activity taking place in the United States and international R&D cooperative programs. This responsibility covers such diverse areas as space, energy, aviation, transportation, science and science policy, environmental R&D as well as agricultural R&D oversight.

Subsequent to the completion of reporting all the Fiscal Year 1986 authorization bills and reports for which the Committee has jurisdiction, the Committee conducted an oversight trip to Europe to review jurisdictional activity taking place in Sweden, Germany, and France. The major emphasis was on potential international cooperation programs in the areas of fusion energy, space, and high energy physics. As can be seen in the Contents page of this report, the Committee conducted parallel meetings with various agencies and institutions and visits to several facilities. In order to accomplish this, the Members chose their participation by subcommittee activity and assignments.

The Committee was ably complemented by a Member of the Committee on Appropriations. Members participating in the European Oversight Trip were:

Committee on Science and Technology

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Robert A. Young (D-MO)
Ron Packard (R-CA)
Harold A. Volkmer (D-MO)
Bill Nelson (D-FL)
Norman Y. Mineta (D-CA)

Committee on Appropriations

Bill Lowery (R-CA)

COUNTRY TEAM BRIEFING—SWEDEN

Date of visit: May 25, 1985
Location: U.S. Embassy, Stockholm, Sweden

The delegation was briefed at the U.S. Embassy by:
Mr. Sherrod B. McCall—Counselor of the Embassy
Mr. Ints M. Silins—Counselor for Political Affairs
Mr. John C. Fry—Counselor for Scientific and Technical Affairs
Ms. Anne Pinkney—Counselor for Economic Affairs

Mr. McCall began the briefing with a brief description of Swedish customs and attitudes. Sweden is considered the most "Americanized" country in Europe and is one of the oldest friends of the U.S. Sweden's policy is to remain non-aligned during times of peace and neutral during times of conflict. Although Sweden is generally perceived to be pacifist because of their history of neutrality, they actually spend a higher percent of their GNP (3½%) on defense than many NATO countries, have more ordinance than other European countries, and have developed their own warplanes. Also, although Sweden is a socialist country, 90% of their industry is privately owned. Their history of labor peace has been broken by recent strikes and protests.

There are five political parties; Social Democrats and Communists (which are socialist) and Center, Moderate, and Liberal (which are non-socialist). Mr. Sherrod stated that the political parties are becoming more polarized; currently voters are about evenly divided between the socialist and non-socialist parties. They will be holding an election in September and the debates are sharper than usual. The economy is the primary issue. The non-socialists have made economic freedom a major theme. Swedish relations with the U.S. is a hidden issue; in particular the U.S. domestic problems are used as arguments against the friends of the U.S. Mr. Sherrod said there are no substantial differences between the U.S. and Sweden and the Embassy enjoys excellent relations with the Swedes. By contrast, Swedish relations with the Soviets have been strained, particularly since the Soviet submarine incident in 1981, which crystalized public attitudes. Polls showed that the Swedish perception of the Soviets as a threat increased from 30 to 80 percent as a result of that incident.

Domestic Economy

Ms. Pinkney, the Embassy's economic counselor reviewed the economic conditions in Sweden. Not only is neutrality an essential aspect of foreign policy, but it is carried over to economics where Sweden also maintains a neutral position. Sweden has not joined the EC because of the political implications. They are active eco-

nomically in the international sphere and are very active in OECD and support GATT. With a population of 8.3 million, they want and need free trade. They have exports and have been very successful with their exports since they devalued the krona, by 16 percent immediately following the election of the Social Democrats in 1982. Their economic balance at this time depends largely on the U.S. and German economy. Sweden is a major exporter of iron and steel, both carbon and specialty steels, as well as automobiles to the U.S. The Swedish subsidy of their steel industry is an issue for the industry. Their civil aviation is not as open as ours. The traditional Swedish ship-building industry is not doing well. Their banking industry is opening up. Forest products are another major export. Sweden currently has a $1 billion trade surplus with the U.S. Ms. Pinkney stated that Sweden needs U.S. high technology products; however, there remains the issue of technology transfer from the U.S. to the USSR through Sweden when U.S. technology products are smuggled to the USSR. Sweden buys their petroleum products from Russia. Trade with the Eastern bloc, especially East Germany, is also very important to Sweden.

Sweden tries to remain self sufficient at the basic subsistence level so they can maintain their neutrality. This has required heavy subsidization of their farmers.

One of Sweden's more serious economic concerns at this time is the significant currency outflow which has occurred over the last six months. This has driven up interest rates which are now at 20%. Inflation has been running at around 7–8%. Unemployment has been relatively low; the Swedes claim about 3% "open" unemployment. When those who are enrolled in government—provided job training programs and other underemployed or discouraged job seekers are included, the true unemployment rate is closer to 7–8%. Health and education are socialized in Sweden and account for 34.7% of the federal employment. Strikes in Sweden are rare. There is a very regressive value added tax on everything, which results in a 75–85% tax rate.

Domestic Political Development

Mr. Silins, Counselor for Political Affairs briefed the delegation on the political issues in Sweden today. Although the Social Democrats still have strong support, there is a growing dissatisfaction over the high taxes. He said increasing numbers of people are saying they would like to be able to keep half of what they make and make a few decisions for themselves. This has resulted in a fairly even split now between the Socialist and non-Socialist parties.

Their philosophy on foreign policy is that no big state should be allowed to have a little state as their back yard, and they have opposed U.S. foreign policy in Vietnam and South America. They are also critical of SDI, and as a neutral country they would not participate in this program. In spite of this, Swedes are very pro-American and are much friendlier towards Americans than Soviets. In a recent poll 40% of those polled would support turning to NATO for help if attacked by the East, while only 6% favored asking for help from the Warsaw Pact if attacked from the West.

In defense, they want to be strong enough to prohibit Sweden from being used as a "stepping stone" between two warring nations. Their relationship with Finland is a special aspect of Swedish foreign policy. They don't want to do anything to allow the Soviets to take over Finland again. Their defense policy is to maintain sufficient deterrence force as well as a strong civil defense program. This includes adding underground civil defense facilities to buildings such as television stations, as well as stockpiling and psychological preparation of the public. Their defense budget is $3 billion a year which represents about 3½% of their GNP or 8% of their total federal budget. Sweden has compulsory military training at age 18 which involves 10 months to 1½ years conscription, refresher training until age 40 and an active duty obligation until age 47. They maintain a cadre of 42,000 men and train approximately 50,000 conscripts annually.

Swedish radio and TV stations are all government-owned; however, newspapers, although subsidized, are privately owned. There are over 100 newspapers in Sweden, some affiliated with a political party, but most are basically independent. The Social Democratic papers have the highest subsidies and the lowest readership, whereas some of the non-socialist papers don't even require subsidies. About 40% of the television programs are American. One channel, a Marxist-Leninist channel, airs selective segments of "60 Minutes". Cable and Satellite TV is growing rapidly in Sweden.

Science and Technology Issues

Mr. Fry briefed the delegation on Sweden's activities in science and technology. Sweden does have a national science policy. They have three Research Councils for medicine, engineering, and science, which are similar to the National Science Foundation in the U.S. They have many cooperative agreements with U.S. agencies such as NRC, DOE, and NSF. Their issues and priorities in science are similar to those in the U.S. of the total budget for R&D, 16% is spent on defense research.

Sweden launched a scientific satellite built by SAAB, Viking, on the Ariane last October 3, to study the magnetosphere. They also participate mainly as a financier on the French remote-sensing system, SPOT. Stockholm will be the site for the 36th annual meeting of the IAS this October.

The joint venture with Fairchild to build the 340 commuter aircraft is now going well. There were problems initially, with Saab being unhappy over Fairchild's engine selection, and Fairchild being unhappy over the rate at which Saab was producing the airframes.

In the area of energy, Sweden has just completed their 12th and last nuclear reactor. It is scheduled to go on line in October 1985. It is made of mostly Swedish equipment. They are switching from the U.S. to URENCO for uranium enrichment services. Forty percent of Sweden's electricity is generated by nuclear power; they have the highest per capita consumption of nuclear power in the world and there has never been a nuclear accident in Sweden. In spite of this record, public opinion in Sweden is anti-nuclear, primarily because of environmental concerns. In 1980 a referendum to phase out the use of nuclear power by the year 2010 was approved by the

voters. They plan to use wind energy and conservation. Currently about half of their power generation is hydroelectric and they use a small amount of oil. They import and export electrical power on the European grid.

They are a member of the European fusion community and participate in JET as well as having their own fusion devices.

Attached is a table comparing science and technology data for the U.S. and Sweden.

COMPARATIVE S&T DATA*: UNITED STATES-SWEDEN

[Figures in percent]

	United States	Sweden
Total R&D by source of funds:		
Industry	50	57
Government	47	40
Other	3	3
Total R&D by performer:		
Industry	72	67
Government and private nonprofit	16	7
Higher education	12	27
Total R&D by character:		
Basic	13	23
Applied	24	17
Development	64	60
Research expenditures by performer:		
Industry	51	24
Higher education	29	64
Government	14	12
Nonprofit	6	.....
Basic research expenditures by performer:		
Higher education	57	88
Industry	19	8
Government	16	4
Private nonprofit	8	.....
Government R&D funding by objective:		
Defense	64	16
Advancement of knowledge	4	40
Space	6	3
Energy	7	11
Health	11	8
Industrial growth	.3	5
Agriculture	2	2
All other	6	15
Industrial R&D expenditures by industry:		
Electrical equipment	20	23
Machinery and computers	13	13
Chemicals/allied products	11	10
Motor vehicles	8	.....
Aerospace	24	21
Instruments	6	2
All other	17	31
Government percent of industrial R&D expenditures:		
Electrial equipment	39	11
Machinery and computers	11	8
Chemicals/allied products	7	3
Motor vehicles	12	.....
Aerospace	72	19
Instruments	16	7
Scientists and engineers engaged in R&D by sector:		
Industry	74	57
Higher education	13	34
Government	9	9
Private nonprofit	4	.....

COMPARATIVE S&T DATA*: UNITED STATES-SWEDEN—Continued

[Figures in percent]

	United States	Sweden
First college degree by field:		
Natural sciences	10	4
Engineering	7	11
Agricultural	2	1
Social sciences	11	10
All other	71	74
Doctoral degrees by field:		
Natural sciences	35	24
Engineering	9	13
Agricultural	3	2
Social sciences	19	23
All other (includes M.D.)	35	38

*Extracted from a draft report prepared by Dr. Leonard Lederman and others of the Natural Science Foundation. Sources for all data are OECD, NSF, and Swedish Government and nongovernment institutions. Figures are the latest available in the 1981–84 period. They may not add in each case to 100 percent due to rounding.

MEETING WITH ASEA-ATOM

Date of visit: May 26, 1985
Location: Stockholm, Sweden
Participant: Mr. Cnut Sundquist, General Manager, Engineering

SUMMARY

ASEA-ATOM, the Swedish company, is continuing to pursue its advanced reactor, PIUS, which incorporates passively-safe design features, although there is little US vendor interest in this concept. The difference between Swedish approaches to reactor safety and the US defense-in-depth philosophy deserves further examination, as well as the higher capacity features that the Swedes have obtained with ASEA-ATOM units versus Westinghouse units. Although the result of the Swedish voter referendum of 1980 was to phase-out the nuclear option after this generation of plants, recent public opinion polls indicate that the nuclear option will continue.

DISCUSSION

The first discussion topic was the status of the worldwide nuclear power business and the fact that ASEA is active in seeking nuclear service business. There was a brief discussion of the prospects for US light water reactor orders and the interest in developing both the modular high temperature gas-cooled reactor (MHTGR) and ASEA's own PIUS concept. (A description of PIUS is included in Appendix A.) Mr. Sundquist noted that the PIUS approach protects the plant investment, as well as public health and safety, and is specifically responsive to sabotage attempts, i.e., the so-called "Swiss syndrome." The Western European countries have taken the approach that reactor systems should be designed to shut down and disconnect from active control room involvement by terrorists for at least ten hours. It is interesting to compare this approach with the NRC's approach of "defense in depth" concentrating on powerplant perimeter delays and detection. There was some discussion of the plant capacity factors which have been achieved on the ASEA plants versus the Westinghouse units in Sweden, since the eleven ASEA plants have demonstrated 83.4% capacity versus roughly 65% for the three Westinghouse units. Mr. Sundquist mentioned his prospective meeting in the US with the TVA and the Oak Ridge National Laboratory regarding PIUS and the discussions which he had held at the NRC with Tom King. The advanced reactor safety design description for the PIUS is included in Appendix A. The document, "Development of General Design Criteria for the PIUS Reactor," describes the certification approach and philosophy, as well as implementation required for US licensing of PIUS. Mr. Sundquist discussed the factors which might account for the difference in capacity and utilization between ASEA plants and

Westinghouse units. ASEA funded early B&W studies on once-through steam generators and have stressed secondary side maintenance to reduce worker exposure. Westinghouse units in Sweden have had steam generator problems and Mr. Sundquist also noted that ASEA has had an advantage in serving as architect/engineer, as well as RM for its units in Sweden. Monitor (Swedish) was A-E for the Westinghouse plants. The ASEA units have shown less corrosion and cracking and their worker exposure is ⅕ to ⅐ of GE's Boiling Water Reactor (BWR) units.

Although the Swedish Nuclear Referendum of 1980 was a decision to phase out nuclear power after this generation of plants is constructed and operated, a recent 1984 poll shows that 77% of the Swedish public expects that nuclear power will not be phased out. The Swedes are finding themselves increasingly constrained in seeking sources of electricity; for example, the government R&D at the Studsvik Center has resulted in a more pessimistic view of what to expect from wind power. As such, the government will require 50/50 cost-sharing for any future wind power projects. When the S&T Committee delegation visited Sweden in 1980, there was much discussion about peat as a resource but the present view is that it will only have a restricted role to play in certain small industrial plant applications. There is increasing environmental resistance in towns north of Stockholm to any expansion of hydroelectric development, which now accounts for roughly 56% of electrical generation. There are only two coal plants operating in Sweden and there is increasing concern over acid rain as a result of evidence that more than 1,000 lakes in the south are effectively dead. One possible major cause of the lake problem is leaded gasoline, since there is limited use of low-lead gasoline. In Sweden, there has been no district heating designed for nuclear plant projects since 1973. In this context, there was some discussion of the potential for using the low-temperature PIUS reactor for district heating applications.

Mr. Sundquist noted that in order to achieve a more rational energy approach, there will have to be considerable turnover at high political levels. ASEA has been interested in selling two 400 megawatt electric units to the Finns, whose IVO utility has conducted a study of seven approaches to providing additional electricity and some district heating. The results of the study rated natural gas from the Soviet Union as one of the less desirable options. ASEA is involved in a program with the Electric Power Research Institute (EPRI) for treating vessel cracks by additions of hydrogen to the system to reduce reactor down time. The plants are monitored on site for levels of certain trace elements as a basis for hydrogen treatment. The discussion closed with mention of government energy R&D in Sweden, which contains no nuclear research and consists chiefly of coal and peat research done at Studsvik. In non-nuclear applications, ASEA has also looked at the Stirling engine for submarines. Mr. Sundquist gave his personal perspective on international cooperation in nuclear energy R&D as "tricky" and thus requiring top management attention. The ASEA facility for non-nuclear PIUS testing consists of a 3 megawatt loop and the first PIUS plant, i.e., the prototype, would be a commercial plant.

SAAB-FAIRCHILD 340 COMMUTER AIRCRAFT FINAL ASSEMBLY PLANT

Date of visit: May 27, 1985
Location: Linkoping, Sweden

SUMMARY

The delegation took a demonstration flight aboard a Saab-Fairchild 340 commuter from Stockholm to Linkoping, Sweden to visit the aircraft division of Saab-Scania where that jointly-produced aircraft is assembled. Mr. Georg Karnsund, President and Chief Executive Officer of Saab-Scania, presented an overview of the company's history and its products, which include automobiles, trucks and aircraft. Mr. Harald Schroder, Vice President and General Manager, discussed the activities of the aircraft division, both military and civil. Mr. Ulf Edlund, Chief Engineer, gave a briefing on the Saab-Fairchild 340 commuter airlines. Following these discussions, the group toured the SF340 final assembly plant.

DISCUSSION

Saab-Scania is a private company engaged mainly in developing, manufacturing, and marketing of products and systems in the transport and communications sectors. Total employment is about 45,000.

The parent company, Saab-Scania AB, consists of a headquarters located in Linkoping, a truck and bus division (Scania), which is the largest part of the company, the Saab car division, and the Saab aircraft division also located in Linkoping. Saab-Scania Combitech AB is a wholly owned group of subsidiaries that manufacture advanced electronics for use in military, space, and industrial applications. It was spun off from the aircraft division to foster the entrepreneurial spirit. It currently consists of over 250 separate companies such as Saab Space and Saab Missiles. Each company has a high degree of independence, but relies on the others as well as the other divisions for technology which can be adapted to its specific products. Saab-Scania Enertech AB was formed in 1984 as another group of wholly owned subsidiaries to produce energy products and systems for process industries.

Saab-Scania had its origin in 1891 in a company formed to manufacture railroad cars. Shortly thereafter, the company hired Gustaf Erikson (the "father of the Swedish automotive industry") to develop an automobile, thereby making Saab-Scania one of the world's oldest automotive manufacturers. Saab was formed in 1937 to produce aircraft for the Swedish defense. The company's first design, the Saab 17, made its maiden flight in May 1940. The Saab 90 Scania, the company's first commercial aircraft, made its first flight in November 1949. To date, over 4000 aircraft have been pro-

duced. Automobiles were added to the product line after the Second World War. Saab and Scania were merged in 1969, bringing together a broad product line in the transport and communications sectors.

With regard to financial performance, Saab-Scania, with the smallest home market of any auto maker, must export to be profitable. In this respect, the company has been highly successful. For example, the Scania Division captured 47 percent of Brazil's truck market in 1984. Of 103,000 Saab cars produced, 34,000 were sold in the U.S. Overall, 64 percent of the company's output was exported in 1984, resulting in a 10 percent return on sales. To maintain these results, the company invested an average 8 percent of sales in research and development over the past 5 years.

Operations of the aircraft division consist of production of the JA37 Viggen multi-role fighter aircraft and Saab-Fairchild 340 commuter airliner, and development of the JAS39 Grippen, a new-generation fighter ordered by the Swedish Air Force.

The Viggen is in full production, currently with deliveries to the Swedish Air Force scheduled to continue through the end of the 80's. It is a fighter designed to perform multiple roles including ground attack, air-to-air, and surveillance. It is the first production aircraft to make use of cannard wings and has a look-down, shoot-down radar.

The Grippen is under development at the present time as a follow-on to the Viggen. It will be 50 percent of its predecessor's size and is projected to cost 40 percent less. The aircraft structure will make extensive use of carbon-fiber composites. To permit dispersing the aircraft, the Air Force requires that it be capable of take-off from certain Swedish roads. The engine is a co-produced (by Volvo) version of the G.E. 404, the power plant of the U.S. F/A-18. Five test aircraft will be constructed, the first of which will be flown in 1987. Serial deliveries will begin in 1992.

Saab-Fairchild 340

In early 1980, Saab-Scania of Sweden and Fairchild Industries of the United States of America signed an agreement to jointly develop, produce, and market a twin-turboprop regional airliner and corporate aircraft, the Saab-Fairchild 340. The agreement was the culmination of extensive technical and market studies conducted first by the individual partners and then, during 1979, jointly.

The studies indicated a substantial worldwide need for an aircraft in this class. The regional airline business is one of the fastest growing segments of civil aviation today. The company estimates a world-wide demand for 1500 aircraft over 10 years. It hopes to capture 25 percent of this market.

The Saab-Fairchild 340 is a modern, highly economical and versatile aircraft designed for all-passenger, all-cargo or mixed configurations.

The aircraft is built for service over the short/medium ranges and multi-stop routes that form the networks of most regional airlines. It can also be used as a government transport, in utility operations and in corporate use.

The Saab-Fairchild 340 is a unique aircraft. It is not only the first airliner ever developed by partners on opposite sides of the At-

lantic Ocean, it is also the first airliner ever developed to meet the highest U.S.-FAA airworthiness regulations as well as the new joint European requirements. Behind the Saab-Fairchild 340 stand two long-established companies, Saab-Scania AB, headquartered in Linkoping, Sweden, and Fairchild Industries, Inc., Germantown, Maryland, USA. The two companies in 1984 employed more than 50,000 people with total sales nearly four billion U.S. dollars.

The Saab-Scania Group is well known for its automotive products, and its Aircraft Division is one of Europe's leading manufacturers of advanced military aircraft. The company is also a major producer of guided missiles and space equipment. The Aircraft Division is producing structural components for the McDonnell Douglas MD-80 as well as for the British BAe 146 short-haul jetliner. To facilitate rational production of the Saab-Fairchild 340, Saab-Scania in 1980 decided to build a new commercial aircraft plant. This 270,000 sq. ft. facility was completed in less than one year.

Fairchild Industries is a diversified aerospace and communications company that builds military and commercial aircraft; manufactures spacecraft, aircraft subsystems, industrial and electronics products, and operates a domestic satellite communications system.

In the military aircraft field, Fairchild Republic has produced many famous aircraft. Its major product for the past several years has been the A-10 Thunderbolt II aircraft. The company now has the USAF contract for a new generation jet trainer T-46A. In the commercial aircraft field, Fairchild Aircraft Corporation has established itself as a market leader for twin-turboprop commuter and corporate aircraft with its Metro, for up to 19 passengers, and Merlin corporate aircraft.

The program moved rapidly from concept to production. The following were the major milestones:

June 1979—Initial agreement between Saab-Scania and Fairchild on joint feasibility studies.

Jan. 1980—First public announcement and decision to go ahead with project definition phase.

June 1980—Engine selection announced.

Sep. 1980—Project definition phase completed and agreement reached for full go-ahead on joint design, development, production and marketing program.

June 1981—Decision to select advanced all-digital avionics system.

July 1982—New Saab-Scania commercial aircraft plant completed.

July 1982—The lead customer, Crossair, confirms order for a total of ten aircraft.

Oct. 1982—Roll out.

Jan. 1983—First flight.

June 1984—Airworthiness certification by eleven countries.

June 1984—The first Crossair aircraft goes into revenue service.

Feb. 1985—Ten aircraft in service with four airlines in Europe and the USA.

Saab-Scania and Fairchild Industries specialists tried to optimize the structural and aerodynamic design to ensure fuel economy and operational flexibility.

To achieve this, a high aspect ratio wing with a new NASA airfoil was used together with a slim, clean fuselage. Extensive metal bonding and flush riveting give clean and smooth airframe surfaces. The bonding also ensures excellent fatigue properties and resistance to corrosion. Adhesive bonding, used extensively in the structural design, saves weight, as do composite materials. The structure is designed for 45,000 flight hours and 90,000 landings. Advanced fatigue-tests of a complete Saab-Fairchild 340 airframe indicate that this goal is well within reach.

The work split between Sweden and the United States is as follows:

Complete Wing	Fairchild Republic
Empennage	Fairchild Republic
Complete Fuselage	Saab-Scania
Final Assembly and Flight Test	Saab-Scania

Among the major Equipment Suppliers are:

Engine	General Electric, USA
Propeller	Dowty Rotol, U.K.
Landing Gear	A.P. Precision, U.K.
Environmental Control System	Hamilton Standard, USA
Flight Guidance and	Rockwell International
Autopilot System	Collins GA Division, USA

The General Electric CT7 engine that develops 1,700 shp was selected as the powerplant for the Saab-Fairchild 340 because of its low fuel consumption, low weight, good maintainability and, last but not least, its technical maturity. Its core engine had, in fact, logged nearly one million hours of operation when the aircraft entered service. The CT7 technology makes it especially suitable for use in noise-sensitive areas and it is also very efficient for hot-and-high operations. The CT7 drives an advanced, constant speed, four-blade Dowty Rotol propeller. The propeller blades use a newly developed high-efficiency airfoil and are made of composite material.

The slow-rotating propellers also ensure that the aircraft meets current and anticipated noise requirements with substantial margins. Fuel is carried in two integral tanks in the wing with a capacity of 850 U.S. gallons. Refueling is accomplished quickly from a single pressure refueling point.

The standard airliner cabin, which is pressurized to maintain sea level cabin altitude up 12,000 feet is very comfortable and accommodates up to 35 passengers. The seat pitch is 30 inches. The cabin layout is flexible and can be matched to different in-flight service levels ranging from simple refreshments to hot meals or increased carry-on luggage facilities.

Embarkation and disembarkation is handled by using the airstair or a passenger airbridge. The height in the aisle area is 72 inches. There is ample room for carry-on luggage in overhead bins as well as under the seats which are specially designed to provide considerable additional volume. The large toilet section is situated in the rear. The galley/carry-on luggage section is located in the front of the cabin.

The Swedish Civil Aviation Administration certificated the Saab-Fairchild 340 regional aircraft on May 30, 1984. One month later,

the international type-approval took place in Linkoping, where representatives from aviation authorities in ten countries signed the type certificate.

The Saab-Fairchild 340 is the first aircraft to have been approved by national aviation administrations in the U.S. and the ten European nations in the JAR (Joint Airworthiness Requirements) group at the same time. Member nations of the JAR group include Belgium, Denmark, Finland, France, The Netherlands, Norway, Switzerland, Great Britain, West Germany and Sweden. Type-approval was received from the twelfth country, Australia, later in the year. The Swedish Civil Aviation Administration was chiefly responsible for the international certification process of the SF 340.

The certification process was preceded by a four-year development and certification program, which included 1,800 flying-hours under various temperature, climate and environmental conditions. Four aircraft were used in the program.

To date, the SF 340 is being flown by six airlines on three continents: two in the U.S. (COMAIR, based in Cincinnati, Ohio, and Air Midwest, out of Wichita, Kansas); two in Europe (CROSSAIR of Switzerland; and SWEDAIR of Sweden); one in the United Kingdom (Birmingham Executive Airways); and Kendell Airlines in Australia. Saab-Fairchild has received firm orders for 65 aircraft with orders and options totaling over 100 aircraft, from regional airlines throughout the world.

MEETING WITH SWEDISH MINISTRY OF EDUCATION AND SCIENCE

Date of visit: May 27, 1985
Location: Stockholm, Sweden

Due to the Committee's interest in general government science policy, consultations were also conducted by the delegation with the senior staff of the Swedish Ministry of Education and Science.

In Sweden the highest governmental science policy body is the Council on Research and Development Policy which is chaired by the Prime Minister. This Council was established in 1982 and it has a much smaller membership than the larger committee which it replaced. In addition to the Prime Minister it also includes the Deputy Prime Minister and a small number of ministers, plus six distinguished professors who serve 3-year terms. The Deputy Prime Minister spends about one-third of his time on science policy matters, and the Council deals with long range policy for research and development.

The Swedish Ministry for Education and Research is the focus for government funding of scientific research. In Sweden it is a basic principle that government support for research should be done through the universities. The Ministry for Education and Research supports most basic and applied research, except in the field of agriculture where the Ministry for Agriculture is the lead agency.

In Sweden, an extensive review of the country's university system was performed in 1977. A major result of that review was a substantial consolidation into the university system of a number of higher education activities formerly conducted separately. For example, advanced training in the arts and the dance is now part of the university system. Another important result was the closing down of a number of schools. It was found, for example, that Sweden was producing many more dentists than could possibly find employment in Sweden, and as a result several schools of dentistry were closed. The Ministry of Education and Research is responsible for the nation-wide administration of the university system and controls the total level of admissions each year. The use of examinations for this purpose has recently been abolished altogether.

The funding of university research is done by means of two mechanisms: block grants and project grants. Block grants are provided directly by the Ministry for Education and Research to the universities. These block grants pay for both research and for the salaries of the university chairs in science and in other fields. Throughout the Swedish university system there are about 200 government supported faculty chairs in science, 300 in engineering, and 400 in medicine. The project grants are administered for the

Ministry by a group of research councils on which professors serve part time.

Applied research and development which is funded by the Swedish government is supported by a series of "Sectoral R & D Units" which are comparable to the U.S. mission agencies. In this area past experience was that there was a good deal of unhappiness with the long-range orientation of the work. As a result, the rule for support now is that grants must yield practical results in 5 years. The focus has been on short term problems in fields such as energy. Funds are divided equally between applied research, which is spent mostly in the universities, and development, which is spent chiefly in industry. However, the university work in applied research has, in general, not been highly successful, while the industry development work has been successful.

Funding for research has been somewhat affected, in recent years, by a government-wide policy of budget reduction. In order to reduce the government's budget, each department and agency has, for the last 6 years, had to absorb an annual cut of two percent of its budget. This policy was instituted as the result of a general feeling that government in Sweden had become too big, and more specifically because a budget deficit had appeared.

In the Ministry for Education and Research the decision was made to give priority to science while deemphasizing education. As a result, funding for education has experienced a good deal of reduction, while funding for research has gone up slightly. The education cuts were justified in part because demand for education in the form of enrollments at the undergraduate level has gone down fast, and in part, as noted above, because the production of professionals in some fields such as dentistry exceeded demand. But currently there is evidence that the demand for higher education again is on the rise, and the Ministry's balance between expenditures for education and research may have to be adjusted, potentially reducing the growth of research funding. One general conclusion which appears to be emerging from this experience is that neither the government not the parliament can or should plan in too much detail, on a discipline by discipline basis. Rather, planning should be limited to the total number of students.

In the field of research opportunities, as opposed to education, a significant amount of study and forecasting has been done and is continuing. A number of 10-year plans in various fields of science and technology were developed, covering such subjects as chemistry, machine design, the geosciences, ceramics, physics, and the computer sciences. These studies are thought of in Sweden as comparable in many ways with the disciplinary studies performed in the U.S. by the National Academy of Sciences.

A significant opportunity to change direction in Swedish science arises when a faculty chair becomes vacant, or, more rarely, when it is decided to establish a new faculty chair. Such an occurrence is seen as an opportunity to respond to new priorities, and since the appointments to fill such chairs is done centrally by the Ministry it can comparatively quickly respond to such priority changes in a top-down manner. For example, in one case a chair in mechanics was changed into a chair in biotechnology, and in another case a chair in pedagogics was changed into a chair in biology. However,

politics occasionally plays a role in such decisions. For example, a proposal to change a chair in the "sociology of work" was opposed by the labor movement, and as a result this chair remained unchanged. Shutdowns of particular subfields of research is occasionally done by the simple expedient of telling the researchers in that subfield that no more money is available.

MBB/ERNO

Date of visit: May 28, 1985
Location: Munich, West Germany

BACKGROUND

Organization and Capabilities.—Messerschmitt Boelkow Blohm (MBB) is presently the largest aerospace R&D firm in Germany and the second largest in Europe (second only to British Aerospace). MBB activities include military and civil aircraft, guided missiles, commercial and military helicopters, conventional transportation and space. The MBB/ERNO Space Division has two primary space facilities, a plant in Ottobrun, where all MBB space developments were centered prior to the merger with ERNO, and the ERNO plant in Bremen.

MBB itself has some 40,000 employees, with about 2,100 in the Space Division. The company annual sales is on the order of 4.85 billion DM, with 300 million of that in the space area.

The space capabilities include expertise in scientific satellites, communications satellites, launcher systems, and systems engineering of major projects such as Spacelab.

Key Personnel.—Dr. Hanns Arnt Vogels is President of MBB. Dr. Othmar Heise heads the Space Division and Mr. Hans Hoffman is his deputy.

Current Space Projects.—MBB/ERNO has a variety of space projects underway. As part of the German contribution to NASA's Galileo mission, MBB/ERNO is responsible for the Retro-Propulsion Module, which has been delivered to NASA for Galileo spacecraft integration and testing. As a company initiative MBB/ERNO developed the Shuttle Pallet Satellite (SPAS), which has now flown twice on the Shuttle. A SPAS derivative, known as EURECA, is being developed for the European Space Agency. MBB is seeking other opportunities for utilization of the existing or upgraded SPAS. MBB is participating in a West German/French consortium for the development of the direct broadcast satellites TV-Sat (Germany) and TDF-1 (France). As a participant in the MESH consortium, MBB is contributing to the ECS-type satellites such as Marecs for Inmarsat. MBB/ERNO has an 8 percent holding in Arianespace and serves as prime contractor for the Ariane second stage. Finally, MBB/ERNO will serve as systems engineer for the European Space Station activities.

ARIANE

MBB/ERNO has an 8 percent holding in Arianespace and has taken important tasks within the Ariane program. As prime contractor MBB/ERNO delivers the fully integrated and equipped second stage, the largest non-French work package. It consists of

development of subsystems (interstage structures, water tank, engine thrust frame, piping and wiring), equipment and integration work and qualification of the complete stage, including the SEP engine.

Ariane's third stage carries the payload into an elliptical orbit. The first European cryogenic stage (propellant: liquid oxygen and liquid hydrogen), it incorporates the highest level of innovation in the project. The HM-7 thrust chamber (injection head, combustion chamber and nozzle), makes a decisive contribution to the capability of this stage.

In addition, other important components have come from MBB/ERNO, such as the LOX and LH2 cut-off valves in the third stage and the telemetry antennas for the entire launcher.

The go-ahead has been given for development of Ariane 4, which will carry payloads of more than 4,000 kg into a transfer orbit by 1986. This performance class will meet requirements for the rest of the present decade.

SPAS

MBB/ERNO has responsibility for the overall project developing and is building the satellite system and integrating it with the payload. MBB/ERNO also contributes a considerable part of the project costs out of its own funds, and therefore, has a substantial share in the financial risk.

SPAS arose from MBB/ERNO's initiative, remains its property, and can be rented from MBB/ERNO for future flights. MBB/ERNO is working to prove that re-usable satellites, combined with the opportunities offered by the Space Shuttle, present an economic way of utilizing space. At the same time, they are securing a leading position on future commercial projects.

SPACELAB

Spacelab is of modular design. During operation, it will remain in a near-earth orbit (200–900 km), anchored firmly in the orbiter's payload bay, and return to earth after seven days. The laboratory and its transport vehicle will then be re-equipped for new tasks. Spacelab is designed for a life of ten years or 50 flights, and the payload weighs between 5500 to 9100 kg.

The Spacelab's modular design consists of three basic systems that can be assembled into different flight configurations:

(1) Pressurized, hermetically sealed cylindrical cabin consisting of one or two modules 3 m in length and 4.06 m in diameter. Here the two to four payload specialists will be able to work as if they were on earth.

(2) Up to five U-shaped pallets, open at the top, on which experiments will be exposed directly to space conditions. The maximum length of the orbiter's cargo bay for the payloads is 16.23 m.

(3) Pressurized automatic supply modules (igloos), which control the experiments and operating systems and perform data checks on all-pallet missions. The systems are switched on and monitored by the Orbiter crew.

Spacelab's internal equipment consists of standard racks built up to international aeronautical standards and equipped with the experiments needed for each specific mission. For manned missions, the core segment is fitted with the main control centre rack (computing/data system) and work bench rack.

The Spacelab consortium was created to develop and build Spacelab. The industrial prime contract was awarded to ERNO (now MBB). The Federal Republic of Germany made the largest contribution to the cost of the development program, with a share of 53.3 percent.

For the subsystem work, the ESA member countries each provide co-contractors in relation to their financial contribution. The companies concerned are AEG-Telefunken, Dormier (FRG), Bell Telephone Manufacturing, SABCA (Belgium), Martra (France), Fokker (Netherlands), Kampsax (Denmark), SENER (Spain), Aeritalia (Italy), British Aerospace Dynamics Group (United Kingdom), and Vereinigte Metallwerke, formerly OKG (Austria).

NASA ordered a second Spacelab flight unit from Europe in January 1980.

As leader of the Spacelab consortium, MBB/ERNO is responsible to ESA for overall concept and management, system integration and testing. MBB/ERNO is also responsible for logistics, and has integrated the European payload for the first Spacelab flight.

GALILEO

The propulsion module for Galileo is the first important subsystem for a U.S. probe that has been developed and constructed outside the United States. MBB is prime contractor for this major portion of the overall project. The deciding factor in selection of the MBB/ERNO propulsion system was its outstanding flexibility and its high performance rate (specific impulse 306 sec.). This engine technology was proven in the Symphonie communications satellites and is also being used in the TV-Sat/TDE-1.

MBB/ERNO is also building the helium interferometer for the Probe. This equipment, which is being developed by the University of Bonn, will make a decisive contribution to analysis of the helium and hydrogen content of the upper Jovian atmosphere and thus to new information about the origin of the planets and the development of the earth's atmosphere.

MAX PLANCK SOCIETY (MPS)

Date of visits: May 28, 1985

The Committee delegation participated in three separate and concurrent meetings with Max Planck Society personnel which are summarized below.

SUMMARY

The Max Planck Society for the Advancement of the Sciences is a large, private organization which plays an important role in the funding and conduct of basic research in West Germany. Because of the delegation's general interest in research funding practices, and because of a specific interest in the possible application of the Max Planck Society (MPS) model to the United States, the delegation met with the Director of International Relations of the MPS and his staff at the Society's headquarters in downtown Munich.

The Society was formed in 1911 for the purpose of supplementing the research done at Germany's universities. It was originally named the Kaiser Wilhelm Society, and it was renamed the Max Planck Society after World War II. Within its original broad function of supporting research not done at universities, the MPS has in the post-war period placed particular emphasis on interdisciplinary research. The Society has a requirement that all research must be published, and it does not support defense-related research. The society does not publish its own scientific journals in order not to compete with existing journals.

DISCUSSION

Organizational Structure

The MPS is organized as a private corporation. It has two kinds of members, scientific and private members. The scientific members are those scientists who are appointed to head the 55 research institutes of the MPS. The private members are individuals, many from industry.

The governing body of the society is the Senate which has 32 members. Each member is elected for a 6-year term by the Society's General Assembly. The membership of the General Assembly includes representatives of the states (länder) (3), the Ministry for Research and Technology (1), the Ministry for Culture (1), the Ministry for Finance (1), and all the 55 institute directors.

Reporting to the Senate are the 3 Scientific Councils: one for biology and medicine, one for chemistry, physics and related sciences, and a third for psychology, education, history and legal research.

The main office is headed by a General Secretary, who supervises a headquarters staff of 300.

Each institute has an advisory board or visiting committee. Members of these boards come mainly from universities, and many are from abroad. None are from the Max Planck Society.

Most of the 55 institutes operated by the MPS are located in West Germany, but a few institutes and research stations are located abroad. An optical astronomy observatory is located in Spain, and a radio astronomy facility is located near Grenoble, France. An Institute for Art History is located in Rome, and an interdisciplinary Institute for Psycho-linguistics has been established in Holland.

Funding and Budget

The Society's total annual budget is about $1 billion. Although it is a private organization, all but 8 percent of this income is derived from governmental sources, about half from the Federal Government, and half from the West German states. Of the 8 percent nongovernmental income, 5 percent comes from the Society's endowment, and the remaining 3 percent from donations.

The Federal government's contribution is in the form of a direct annual appropriation channeled through the Ministry for Research and Technology and a governmental organization known as the German Research Society which is a rough equivalent of the U.S. National Science Foundation.

The size of the contribution from the 11 states is calculated as a percentage of their GNP, and this formula is reviewed every 4 years. Last year the percentage was 3.5 percent. A few of the states have no MPS institutes located within their borders and this occasionally becomes an issue. In cases where a state urges the establishment of a new institute, it may be asked to provide a higher share than normally of the operating costs. The states sometimes try to influence the decisions to close an institute, but the Society resists such influence.

Each year the institutes submit their budget proposals to the Society's main office. A Committee of the Society Senate reviews these budgets and discusses priorities. This committee includes both scientists and politicians and is also responsible for medium range financial planning. To maintain continuous contact between the main office and the institutes, 4 liaison officers have been appointed.

Although the decisions about scientific priorities and about personnel are centralized, certain other functions are decentralized. The acquisition of research equipment and facilities costing less than 10,000 DM ($3,500) is decided by each institute. Items above this amount must be reviewed at MPS headquarters where a special commission reviews such requests. A total of 100 million DM ($35 million) are expended annually for this purpose, divided about equally between facilities and equipment. The acceptance of foreign guests is jointly decided between the institutes and the main office. Such guests must be specialists in some field as the institute, and the Institute Director must justify the invitation of a foreign guest. At headquarters, political judgments, for example concerning the emphasis or deemphasis on particular countries, is applied.

The Research Institutes

The 55 research institutes operated by the Max Planck Society are the locus of the Society's research work. Located throughout West Germany, they vary in size. They share the characteristic that each institute is headed by a director who is a prominent scientist. Each institute specializes in a particular field of science, and the director is selected because of his outstanding record and reputation in that field of science.

The Society will establish a new institute to carry out research in a particular field only if an outstanding scientist in that field can be found and persuaded to become its director. Conversely, with the retirement of an institute director, the Society frequently will close his institute and use the funds to set up an institute in a new field. Before such a decision is reached, an evalaution is done to determine whether the work of the existing institute should be continued with a new director.

When the establishment of a new institute is under consideration, extensive discussions are conducted within the MPS. In addition, consultations take place with external experts and with the German Research Society. The first question to be addressed is: Is there no other place in West Germany that can do this research, either in the universities or in industry? Once it has been determined that the Society should seek to establish a new research institute, the next question is: Can an outstanding scientist be found to head it?

About 20 percent of the current institute directors have been recruited from outside West Germany, and on the average one new institute is established each year. Institute Directors are appointed for 7-year terms. This permits the replacement of directors who turn out to be poor managers or who are not good scientists. However, such individuals have tenure at the institute.

One representative example of an institute that had been closed since 1970 was discussed. An Institute for Research on Silicates had been founded in the 1920's. Its mission then was to conduct basic research in support of West Germany's optical industry, and it had good success. The recent evaluation found however, that 9 West German universities now are active in this field of research. The Silicate Institute was transferred to the MPS's sister organization, the Frauenhofer Society which emphasizes applied research.

The Max Planck Society is finding that the closing down of an institute is very costly. Because of changes in West German employment laws, it is now a requirement that individuals being laid off must be provided with 5 years of severance pay. As a result it may not be possible to maintain the average rate of one institute closing a year.

The number of patents arising from the work at the institutes varies. A few institutes produce a significant number of patentable inventions. A separate corporation manages such patents, and an effort is made to sell licenses to industry. Under West German law one-third of the proceeds must go to the inventor, while the other two-thirds go to the MPS.

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Professional Staff

The total staff of the MPS is 11,000. Of this number, 4,700 are junior and senior scientists. Of these scientists, approximately 2,000 are younger, salaried investigators, and 20 percent of these have 5-year contracts and must leave after their contract is up. Another 1,200 are more senior guest professors from elsewhere in West Germany who stay for a 2-year period. Another 1,300 are foreign guests who come to the institutes on fellowships sponsored either by their home country or by the Society. Twenty percent of these foreign guests are from the United States. The younger researchers are all post-doctorals, and the institutes do not award any degrees including the Ph.D. Salaries of the paid the staff match university salaries, except in the case of Institute Directors where significantly higher salaries are offered to attract the best talent.

The Frauenhofer Society

While the Max Planck Society concentrates on basic research, the Frauenhofer Society, which the delegation did not visit, supports applied research. It operates between 30 and 40 institutes. Roughly half of its funds come from governments, while half comes from industry in the form of contract research.

Location: Max Planck Institute for Plasma Physics (IPP), Garching, West Germany

Magnetic Fusion

The FRG experiments at the Institute for Plasma Physics at Garching are very complementary to US research activity at both Princeton, N.J. and Oak Ridge, Tenn., and international cooperative agreements are ready to be signed on this joint research. The staff at the IPP believes that a lower-cost ignition experiment is important to physics, but of more limited value for magnetic fusion technology development.

The Max Planck Institute for Plasma Physics at Garching, near Munich, houses a large effort in magnetic fusion and related fields with roughly 1,000 people involved in IPP activities. A short history of the IPP, including a chronology of major milestones, is included in Appendix B.

The delegation met with Dr. Michael Kaufman, one of the Assistant Directors at the IPP, because Dr. Klaus Pinkau, the Director, was attending the JT-60 facility dedication in Japan. The delegation members discussed the activities and role of the Next European Torus (NET) design team at IPP headed by Dr. Roberto Toschi. The relationship between experiments carried out in the Poloidal Divertor Experiment (PDX) at Princeton, relative to the ASDEX machine at Garching, was discussed. The US and West Germany are about to sign a technology agreement covering the ASDEX upgrade, a $60 million capital cost project, and related US experiments. There was brief mention of the IAEA INTOR exercise and the fact that the US Congress had some concerns about such an international activity with technological ramifications since it involves the USSR. The ASDEX upgrade is in its predesign phase; the concrete building with extra-thick walls, which will house the device, is quite far along in construction. The delegation visited the ASDEX facility, which is focused on plasma cleaning experiments with the ASDEX tokamak as described in Appendix C.

The IPP group has also been conducting experiments on the WENDELSTEIN VII-A stellarator, a machine in the same category as the Advanced Toroidal Facility (ATF) at the Oak Ridge National Laboratory. The WENDELSTEIN VII-A is also being upgraded, but the VII-A-AS facility, as it is known, will use the existing building and much of the diagnostic and auxiliary equipment of the VII-A. The total capital cost is expected to be a little greater than $10 million because of this use of existing building and equipment. The WENDELSTEIN VII-A stellarator, which has operated since 1976, is described in Appendix C. The AS device is also to be covered in a US/IEA implementing agreement to be signed very soon. The experiments planned on both the ASDEX Upgrade and W-VII-AS are described in Appendix C. A brief discussion of INTOR and NET cooperation is also included. Finally, a description of ZEPHYR, a planned ignition experiment which was deleted because of budget cuts, is included in Appendix C. Dr. Kaufman and his colleagues provided the delegation with their views on a lower-cost ignition experiment. They believe such an experiment is important for the physics element of magnetic fusion but does not do as much for technology development, since it must be done in a tokamak, and tokamaks probably will not be commercial power reactors. However, the IPP staff did recognize the fact that the US program needs a focus beyond TFTR and that, in fact, a lower-cost ignition device may be a political necessity for the US program. The IPP group briefly reviewed the USSR fusion program and pointed out that the program has a near-term emphasis on achieving a fission/fusion hybrid, a thrust which would be much more difficult to carry out politically in the US, although technologically it is more straightforward than electrical power generation through magnetic fusion.

Location: Munich, West Germany

Part of the delegation was briefed at the Max Planck Institute for Extraterrestrial Physics.

The work of the Institute for Extraterrestrial Physics can be divided into three methodologically differentiated parts: first, astrophysical measurements; second, in situ measurements in space; and third, laboratory measurements. Their resources are divided as follows: about 60 percent goes to various astronomical observations, 30 percent to in situ observations, and 10 percent to laboratory work. This Institute has several cooperative programs with NASA.

DISCUSSION

The efforts of the Extraterrestrial Physics Institute are focused on astrophysics and the near-earth space physics. These activities include the study of X-rays, particles, geomagnetism, gamma rays, as well as space plasma physics. The Institute receives ninety percent of its instutitional funding from government, with fifty percent from the federal government and fifty percent from the state governments. The additional ten percent comes from Max Planck Society income in the form of royalties, etc. In addition to the institutional funding, project money flows to the Institute from the BMFT (Ministry of Research and Technology). The annual institutional budget of the Extraterrestrial Physics Institute is currently approximately 20 million DM ($6.7 million U.S.). The results of the Institute's research are widely published in both European and United States scientific journals.

Reimar Luest organized the Extraterrestrial Physics Institute 20 years ago and served as the first Director. Klaus Pinkan built up the X-ray astronomy expertise as the second director. Science instruments are mostly built in-house with some subcontracting to industry. The Institute has built two satellites in-house. Most of the Institute's efforts are on the development of instruments. The Institute prefers free-flyers to Spacelab sortie missions.

The Institute has had strong, intimate and good relations with NASA, beginning with sounding rocket launches from Wallops in 1966. In 1969 a German research satellite was launched from the Western Test Range of the U.S. The Institute also flew instruments on Helios, which was built mostly in West Germany and launched by the United States.

The Institute views the Space Station as an opportunity for Europe. The Institute is mostly interested in the Space Station as a platform for science instruments. Science instruments needing large antennas can be helped by the station. There is some concern regarding the resource requirements going into the station and whether there will be resources available for science instruments.

X-ray Astronomy.—X-ray astronomy involves looking at the hottest parts of the universe (millions of degrees). The first measure-

ments of the sun were made using V-2 rockets. West German X-ray astronomy started in the 70's with balloons.

The Institute provided a number of instruments for EXOSAT, a satellite built by MBB. EXOSAT instruments are focused on the energy range between 0.1 KeV and 50 KeV. Cosmic X-ray sources are being identified and the data being collected is furnishing information about their exact location, structure, spectral composition, and time-related variations. The Extraterrestrial Physics Institute is a major user of data from EXOSAT.

A follow-on mission, called RORSAT is being planned. The Einstein satellite carried a telescope 56 cm in diameter. The RORSAT satellite is planning on a telescope 84 cm in diameter. There will be substantial NASA involvement in RORSAT. The RORSAT will be launched on the Shuttle in the late 1980's and is being designed for a three or four year lifetime.

Gamma Ray Astronomy.—The Institute has a gamma ray instrument of Ulysses, the solar polar mission planned for launch next year. International collaboration is very important in this area and the Institute is deeply involved in international collaboration on the Gamma Ray Observatory being developed in the United States.

AMPTE (Active Magentospheric Particle Tracer Explorers).—AMPTE is a three satellite project of the United States, the Federal Republic of Germany, and the United Kingdom. It uses artificial injection of rare ionic species for long-range tracing of mass transport into and through the magnetospheric system. The Institute started its space program in 1964 and developed the technology of releasing barium clouds in space to investigate the interaction of the resulting plasma with the solar wind and the magnetic field in space. This technique has reached a high degree of sophistication in the AMPTE spacecraft, recently launched, which is now taking data successfully. This spacecraft will make several barium releases over the next several years. The AMPTE satellite was built in-house at the Institute for a total cost of 13 million DM. The total cost of the spacecraft and experiments, plus the data analysis which will last for several years, will be approximately $12 million (U.S.).

COUNTRY BRIEFING—AMERICAN EMBASSY BONN, FEDERAL REPUBLIC OF GERMANY (FRG)

Date of visit: May 29, 1985
Location: U.S. Embassy, Bonn (FRG)

On Wednesday, May 29, 1985, the delegation visited the United States Embassy in Bonn and was briefed by the staff. Charge d'Affaires William M. Woessner greeted the delegation and was joined by Minister-Counselor for Economic Affairs William H. Edgar, Counselor for Scientific and Technological Affairs Robert G. Morris, Deputy Counselor for Political Affairs Thomas Weston, and Counselor for Agricultural Affairs Richard Barnes. Mr. Harry Raddy, Deputy Chief of the United States Information Service office also participated in the briefings.

At the time of the delegation visit the office of Ambassador was vacant due to the recent retirement of Arthur F. Burns.

Relations between the United States and West Germany were extremely cordial, the delegation was informed that the recent visit to West Germany by President Reagan had been an overwhelming success and that his visit to the Bitburg Cemetery had been well received throughout West Germany.

The German economy is generally very strong and their Gross National Product is currently growing at an annual rate of 2.5%. While they suffer an unemployment of approximately 2.3 million in a population of almost 62 million there does not appear to be any signs of early relief. Labor costs in West Germany are very high and at the present the majority of new investment capital is going into technology such as robotics which replaces workers with machines.

Economic relations between the United States and West Germany are very good at this time. There is an exceptionally high degree of agreement between the West German and American governments on virtually all economic and trade issues.

The West German system of government is a parliament with a lower Chamber (Bundestag) and Federal Council (Bundesrat). The Federal Republic consists of ten states or Länder. West Berlin is closely integrated into the political, economic, and administrative system of the Federal Republic.

The present government is a coalition of the Christian Democratic (CDU/CSU) and Free Democratic parties formed in 1982 and renewed in March of 1983. The opposition party, the Social Democrats, have recently picked up strength in elections in the state of Westphalia. These elections may have long term implications which are not favorable to the present government since one-third of the population of the country is in Westphalia.

There are several areas of ongoing concern between the United States and West Germany which include the level of burden-sharing to be undertaken by the West German Government to support the continued permanent forward deployment of 260,000 American troops. Many of those troops are still quartered in barracks facili-

ties that go back well before World War II. Most of those facilities are now in need of replacement.

Members of the delegation expressed a number of questions on areas of concern. They were told that the U.S. Foreign Commercial Service of the Department of Commerce maintains a staff of ten Americans and 20 West Germans who work full time to encourage American imports and improve our balance of trade. They were also informed that the United States Customs Service works directly with the FRG government to prevent the sale of certain items of high technology to the nations of the Warsaw Pact. There is continued disagreement between the United States and the FRG on the issues of the Soviet gas pipeline and trade with Cuba.

The delegation asked if the West German people were supportive of the continued presence of more than a quarter of a million American troops in the FRG. They were told that there is very strong support among the West German people for a continued U.S. presence. The Embassy estimates is that about 80% of the West German people are in favor of maintaining American force levels at the the present strength.

It was also pointed out that there is now wide support of the deployment of the Pershing II missile in the FRG. While the West Germans, like most people, do not want new weapons systems in their back yard, they accept them because of the Soviet menace on their frontier.

Several members of the delegation expressed interest in the views of the FRG government and people on the Strategic Defense Initiative. They were told that Prime Minister Helmut Kohl has expressed interest in FRG participation in SDI. West German industry has expressed strong interest in SDI. However, there is concern among Western Europeans generally about SDI because they generally do not understand the proposal, they usually do not like new weapons systems, and they perceive that the United States would be protected while Western Europe would not. There is concern that the U.S. advocacy of SDI as an alternative to "immoral" nuclear weapons will weaken the public support for nuclear weapons during the transition period before SDI is in place. The jeopardy is great if SDI doen't work.

There is also concern in West Germany that the United States government policy on European cooperation has not yet been defined in a number of areas of leading-edge technologies such as information technology, superfast computers, advanced laser technology and advanced materials. Many European firms would very much like to participate in the research efforts, but they fear that they may not get access to the most advanced technologies.

Finally, the delegation was told that the West Germans are presently making large and impressive increases in space activities. They have recently made major commitments for the next five years. West German industry has a very high degree of self confidence and shows a willingness to compete directly with American industry on an equal basis.

WEST GERMANY FEDERAL MINISTRY FOR RESEARCH AND TECHNOLOGY (BMFT)

Date of visit: May 29, 1985
Location: Bonn, FRG

BACKGROUND

In December 1972, following the federal elections, the federal chancellor issued an organization decree redefining the responsibilities of a number of federal ministries and created the Federal Ministry for Research and Technology. The newly founded Federal Ministry for Research and Technology ("Bundesministerium fur Forschung und Technologie") (BMFT) was given the responsibility for: (a) general promotion of research; (b) planning and coordination of research; (c) technological research, development, and innovation; (d) data processing; (e) nuclear research and technology; (f) space research and technology, and (g) aeronautical research.

In addition, the BMFT became responsible for basic issues and the coordination of communications technology, as well as for the coordination of civil and military aeronautical and space research and development.

In the spring of 1978, under the responsibility of the BMFT, a concept for coordinating research and development activities within the Federal Government was developed. The main points of this scheme are: (1) to prevent unnecessary duplication of research efforts in the interest of making effective use of the funds earmarked by the Bund (Federal Government) for research and development; (2) to bring together the research and development activities pursued by several federal ministries in some form of cooperation if such research is being carried out in the same sector; and (3) to coordinate the research and development activities of the federal ministries as the essential precondition for (a) a sensible international cooperation of the Bund in various research and development sectors, and (b) a useful cooperation with the Länder (State government), the academic world and industry in the Federal Republic.

The Federal Ministry for Research and Technology (BMFT) is responsible for the space research and space technology program of the Federal Republic of Germany. The same Ministry is also in charge of the coordination within the departments of the Federal Government responsible for application, industrial policy, international and legal matters.

In the scientific and technical field, BMFT is supported and represented by the Deutsche Forschungs-und Versuchsanstalt fur Luft-und Raumfahrt (DFVLR) which contributes substantially to planning and implementing the program. Its duties include:

—the preparation of program planning.

—program management on behalf of the commissioning agencies.
—research in the fields of space technology and its applications, with special emphasis on satellite communications and navigation, remote sensing, microgravity research and space medicine, and including the support and coordination of external scientific users.
—providing experminental and test facilities for specific space-related purposes.
—planning and implementation of mission operation for space projects.

Besides DFVLR, the Industrieanlagen-Betriebsgesellschaft (IABG) and industry provide experimental and test facilities.

Moreover, BMFT in its planning activities seeks advice from a number of permanent consultant bodies and ad hoc committees representing research, industry and users.

The major part of the program is implemented within the framework of the programs of the European space organization, ESA.

National and bilateral activities constitute another important element. They serve the scientific and technological preparation of participation in international programs, comprising all aspects of the utilization of space missions and including independent space missions, especially as far as they serve exclusively or mainly national user entities.

Organization—The Bundesministerium für Forschung and Technologie (BMFT—Ministry for Research and Technology) is the West German government agency with overall responsibilities for scientific research. The Deutsche Forschungs -und Versuchsanstalt für Luft und Raumfahrt (DFVLR—German Aerospace Research Establishment) is a public corporation managing all Government engineering and test centers. DFVLR conducts aerospace R&D and carries out project planning and implementation for BMFT. The Deutsche Forschungsgemeinschaft (DFG—German Research Association) is a self-governing organization of 31 universities and five scientific societies and institutes that allocates federal, state and private monies to its members. The main scientific capability is concentrated in the institutes of the Max Planck Society (MPS).

Personnel.—Dr. Heinz Riesenhuber is Minister for Research and Technology. Dr. Wolfgang Finke is Minister Director of the Division for Space, Transportation, Medicine and Biology Research of the Ministry. Dr. Hermann L. Jordan is Chairman of the DFVLR, Mr. Horst Schreiber is Director of the Project Executive Branch (BFT) for DFVLR.

Budget.—Approximately $300 million annually; $150 million of that is the FRG funding for the European Space Agency (ESA).

Facilities.—(1) Major government aerospace engineering facilities at about 30 separate institutes under the DFVLR, with chief research centers at Braunschweig, Porz-Wahn, Stuttgart, and Oberpfaffenhofen (large wind tunnels, thermal vacuum chambers, flight simulators and radiation facilities). (2) Major scientific laboratories in 54 Max Planck Institutes; 27 technical universities, 17 universities, 7 Fraunhofer Institutes, and 4 observatories. (3) A satellite control and data center has been installed at Oberpfaffenhofen to work with NASA and ESA networks on control of and data acquisition from West German spacecraft. The FRG tracking network has

a primary tracking station at Weilheim, West Germany and automated telemetry stations in Finland, Iceland, and Canada. (4) The BMFT is supporting a dedicated laser and VLBI observatory, located at Wetzell, and a mobile laser ranging station which are expected to become operational in 1983.

DISCUSSION

Dr. Riesenhuber, Minister for Research and Technology, began the discussion with an opening statement. The Ministry has a total annual budget of 7.2 billion DM (=$2.4 billion U.S.). A summary of his remarks follows:

In general there is good cooperation in research and development and defense activities between the United States and West Germany. We need a free flow of science and information so that our countries can grow together. Not only does cooperation fit with friendship, but competition fits with friendship as well.

The Ministry for Research and Technology devoted 27 percent of its resources to basic research in 1982. This has increased to 33 percent at present with plans to increase further to 36 percent. Although the Ministry looks favorably on cooperation in large science programs, location of the project is often a problem. Location is a bigger problem with large particle accelerators than with ocean and space activities.

With regard to the United States invitation for European participation in the Space Station, West Germany looks forward to this cooperation through the European Columbus program. West Germany along with Italy has played a leadership role in Europe in developing the Columbus concept. The hardware developed under the Columbus concept will be added to the United States space station but will not be an integral part. This will be an excellent field for cooperation in high technology, and Europe will cooperate with its best industry teams. In discussing the legal status of space station cooperation, Dr. Riesenhuber stressed the need for a good and sound legal basis, a good and fair partnership, and a free flow and exchange of know how.

U.S. DELEGATION: What are BMFT's budget projections? How does West Germany set priorities?

Dr. RIESENHUBER: The BMFT budget is projected to increase 0.9 percent per year. The Ministry is working under a constrained budget. The Ministry is cutting down energy research to make room for new projects, technology demonstrations and soft energy technologies. Technology is available where there are markets. Government continues to have a role in safety research. Efforts are being increased for biotechnology, materials sciences, life sciences, and space. With regard to space an additional 4.6 billion DM will be required for the space station activities. One-half will come out of the BMFT budget and one-half will be provided from the general budget. It is easy to start new projects, but difficult to stop old projects.

U.S. DELEGATION: Congratulated Minister on his leadership in promoting European cooperation. Why did West Germany step out in this direction?

Dr. RIESENHUBER: We have always felt that autonomy in Europe was the wrong way and provides sub-optimal results. Only with close cooperation in science and technology can the free world grow and expand our economies. Space is a most attractive place for cooperation:

In basic research it is entirely conceivable and possible that cooperation might be expanded on "big science" projects between Europe and the United States. In years past such cooperation has worked well. For example, the Deep Sea Drilling Project was a success, and involved strong international participation. That success may in part have been because the project was not bound to a particular site. The same is true for international cooperation on space projects. It is when the question of site arises that problems begin.

On the SSC (Superconducting Super Collider) we are in the early stages. There are already physicists from different countries working together on the definition of this project. The LEP (Large Electron Positron) Accelerator is working successfully, and HERA (High Energy Research Accelerator) to which Germany has contributed 1.3 million DM, is making progress. The same can be said for the Heavy Ion Accelerator Facility, for which 300 million DM has been contributed, and the Synchrotron Radiation Facility. On all of these we have cooperation among many European countries. This is similarly true vis-a-vis the United States in case of the upcoming X-Ray satellite Rosat Roentgen Satellite, and the Large Oceangoing Drilling Vessel.

U.S. DELEGATION: Can there be a free world CERN or a free world ESA?

Dr. RIESENHUBER: We must first find the project and then define the right agency or institution. But the best way to grow together is to work together.

U.S. DELEGATION: Is the time right to propose joint cooperation for the next fusion project?

Dr. RIESENHUBER: Cooperation between United States, Europe, and Japan might be possible. Fusion research is still in the basic research stage and non-competitive. It is large in cost and might be a good prospect.

U.S. DELEGATION: There is currently an international geothermal research project in New Mexico. I am concerned over the impact of possible budget reductions in West Germany and Japan.

Dr. RIESENHUBER: We are currently looking at the technical difficulties with this project.

U.S. DELEGATION: Is West Germany going to cooperate with the United States on SDI?

Dr. RIESENHUBER: With regard to civil space cooperation we have reached decisions. With regard to SDI it is not so well defined. Many questions remain. What would be the nature of the cooperation? What concepts are being considered? How do we make the best civil use of what might come up?

U.S. DELEGATION: But SDI is only basic research?

Dr. RIESENHUBER: We would need to make some decisions regarding what is classified vs. what is non classified. The different steps have not be defined.

U.S. DELEGATION: What about ESA and the Hermes project proposed by France?

Dr. FINKE: ESA has decided to go forward with two major projects (Ariane and Columbus) as well as increase basic research 5 percent per year over the next five years. The ESA council took note of the French Hermes proposal and welcomed France's offer to keep governments informed. Large money would not be available until approximately 1988 at the earliest.

The following discussion on nuclear fission and fusion is based on a summary of the topic which was raised at the several meetings during the day with the ministry.

Participants from the FRG were:

Dr. Riesenhuber, Minister of Science and Technology (FRG)
Mr. Heyl, Office of Large Research Establishments and Nuclear Fusion
Dr. Gunter Lehr, Director General, Energy, Biology, Ecology
Dr. Manfred Popp, Deputy Assistant Secretary for Nuclear Energy and Energy Research
Dr. -Ing. Helmut Schug, Ministerialrat (HTGR Program)

SUMMARY

The Federal Republic of Germany is keenly interested in the US development program for the Modular High Temperature Gas-Cooled Reactor (MHTGR), but has not indicated precisely how the FRG would participate with the US in such a program culminating in the testing of an MHTGR nuclear steam supply system. The FRG officials were concerned about whether the cuts in the US Magnetic Fusion Energy program were a result of a major policy redirection on the part of Congress and/or the Administration or mainly driven by budgetary deficit concerns. The FRG Research and Technology Minister, Dr. Riesenhuber, indicated interest in cooperation on a large fusion project if resource constraints require such a joint venture.

DISCUSSION

The discussions with Temperature Gas-Cooled Reactor (HTGR) and the two separate FRG companies, HRB and KWU, have been pursuing independent HTGR designs. The DMFT officials were particularly interested in the status of the US HTGR program and the prospects for funding in FY 1986 and beyond. The delegation reviewed the history of the US HTGR program and reemphasized the fact that the present thrust toward a Modular HTGR design is the result of the Fuqua/Lloyd initiative which was contained in a letter sent to Secretary Hodel in November, 1983. The delegation members indicated their concern that the FY 1986 DOE request was $9 million less than the FY 1985 appropriations level and mentioned that the Committee added $10 million in order to sustain momentum in the MHTGR program. A brief description of the KWU/Interatom HTGR module approach is included in Appendix D. HRB, which is 45% owned by GA Technologies Inc., has been involved in HTGR technology development for a number of years and has adopted an in-line concept (steam generator on top of the reactor core). The US technical community opted for the side-by-side MHTGR design in March of this year. The Committee has

been encouraging the DOE to focus the program toward an ultimate validation of a test article which could presumably be an MHTGR nuclear steam supply system (NSSS). A description of the HRB in-line concept is included in Appendix D.

The discussions on magnetic fusion technology chiefly focused on prospects for international cooperation. The FRG officials indicated their satisfaction with the IEA/US agreements to be signed on ASDEX and W-VII-AS cooperation, as outlined in the section of this report on the delegation visit to the Max Planck Institute of Plasma Physics at Garching. The West Germans do not seem to be thinking in terms of a specific large project as a vehicle for cooperation with the US through the OECD, but are thinking in more general terms of the need for cooperation to reduce pressures on individual nations' budgets. Minister Riesenhuber echoed this message in his discussions with the delegation when he indicated a willingness to cooperate with the US *if* a future fusion project would require such a large commitment of funding that there would be no possibility of the JET group or the US going it alone. The FRG officials did not seem as familiar with the Committee's thrust toward a US lower-cost ignition device, as were the physicists at IPP, but talked in more general terms about prospects for cooperation in the context of their experience in high energy physics cooperation at CERN in Geneva.

The FRG and the delegation agreed that international cooperation in areas such as ocean drilling and space were probably easier ventures institutionally, since they avoid the issue of siting a facility. In the case of magnetic fusion, of course, the siting issue is what delayed the go-ahead on JET. The West Germans discussed the JET experience as an example of "community complementarity" and then asked the question—when do we reach such a costly step in fusion that we must combine financial resources? The Minister reviewed the history of government and industry support of the HTGR and specifically mentioned the KWU involvement in recent years. He then turned to a discussion of the FRG's THTR (a 300-megawatt electric reactor being constructed at Schmiehausen), which is expected to come on-stream. He recounted how the present government got the project back on track after cost escalation and schedule slippage. Dr. Riesenhuber made no detailed mention of the US program or the potential role of the FRG in it through government or industry involvement. He discussed European fast breeder cooperation where the UK has recently joined the team. He also reviewed progress on SNR-600, the West German fast breeder reactor project, where until 1982 costs were out of control, but it is now on track and will be completed with nearly 50/50 government/industry cost-sharing. There was a brief mention of nuclear waste cooperation in terms of emplacement of US spent fuel and waste in the salt mines in the FRG. The delegation asked whether it was timely for the DOE to approach the FRG on magnetic fusion cooperation and the Minister replied by discussing the European NET activity (which goes on at the IPP at Garching), but there was no discussion as to whether or not the next project should be an ignition step. Dr. Riesenhuber also alluded to US and OECD cooperation through an international activity such as INTOR, where the US delegation had previously expressed res-

ervations in terms of Soviet involvement. He recounted the fact that the FRG magnetic fusion activities have been integrated in the OECD program in a complementary manner. The Minister did mention that a demo reactor device would be very costly). He closed the fusion discussion by suggesting that it is important to explore more precisely what kind of basic research activities can be undertaken short of such an ambitious project.

MEETING WITH THE DIRECTOR OF INTERNATIONAL AGRICULTURAL AND FISHERY POLICIES (FGR)

Date of visit: May 29, 1985
Location: Bonn, FRG

Wednesday, May 29, 1985 Congressman Harold L. Volkmer met with Rudolf Genske, Department Director of International Agricultural and Fishery Policies and Minister of Food, Agriculture and Forestry for the Federal Republic of Germany. The discussion, dealing with agricultural issues, was held in Bonn.

Mr. Genske began the meeting by posing three questions of importance to West Germany: (1) where does the decline in farm income come from?; (2) what can be done in new General Agreement on Trades and Tariffs talks and what would be the theme of Secretary John Block's talk to the Council on Food?; and, (3) what provisions and programs will be in the new U.S. farm bill?

Director Genske's comments touched on a range of agricultural issues mostly dealing with low prices and high production. He said the West Germans suffered an 18 percent decline in 1984 farm income. The one percent price cut proposal before the European Economic Community (EEC) ministers would not provide any reduction of worldwide production, he said. He was concerned that the one percent proposal would not cut price and production at the same time. He expressed a desire for a rearrangement of grain standards which would include a separate standard for feed wheat. He also expressed his opinion that price cuts were ineffective in reducing production. He said that the present worldwide glut of wheat could be better handled by having a feed wheat standard with lower prices.

Director Genske further stated that if the United States support price and cash price for wheat did go to market level, a trade war between the U.S. and the E.E.C. would result. He cautioned that a trade war must be avoided.

Director Genske noted that the reduction in dairy herds and livestock production in West Germany has caused the reduction of imports of feed stocks and corn gluten from the United States.

Genske added that in the September round of E.E.C. meetings on agriculture, the West Germans would support a proposal to reduce production by providing for a set aside acreage for environmental and conservation programs. This proposal is the only way, he said, to get production in balance. The West Germans are supporting the United States for a new round of G.A.T.T. agreement, devising a method to compensate farmers for reducing production. He admitted that the E.E.C. may have difficulty in providing funds for a set-aside program. Director Genske also said it would be advantageous for the E.E.C. and the United States to have bilateral discussions on reductions in wheat production by both countries.

PARIS-COUNTRY TEAM BRIEFING

Date of visit: Thursday, May 30, 1985
Location: American Embassy, Paris

The Delegation was briefed by members of the Country Team at the American Embassy including John J. Maresca, Deputy Chief of Mission; Gerald A. Rosen, Minister Counselor for Economic Affairs; Adrian A. Basora, Counselor for Political Affairs; and John P. Boright, Counselor for Scientific Affairs. Topics included domestic, political and economic developments, U.S.-French relations and science and technology issues.

Domestic Political Developments

France was described as entering a period of heightened political activity with legislative elections scheduled for March of next year. President Mitterrand's popularity has declined markedly as measured in public opinion polls, and the conservative opposition parties now expect to win control over the National Assembly. Should this happen, a constitutional crisis of sorts could result with a President of one party coming into confrontation with an Assembly controlled by another. Under the French Constitution, the President does not have the power to veto acts passed by the legislature, and could be faced with the prospect of having to sign into law a variety of unpalatable legislative offerings. This could possibly force Mitterrand to resign.

While Mitterrand's personal popularity has tumbled, public approval ratings for former Prime Minister Raymond Barre have risen to 61%. Gaullist Party leader Jacques Chirac received a 47% approval rating and former President Giscard d'Estaing received a mere 30% in the same poll. Mitterrand's term as President extends until 1988. While Mitterrand could dissolve the Assembly and call elections at any time, it is highly unlikely that he would do so prior to the scheduled March elections as long as the political fortunes of the Socialists are in decline. Much of the criticism of the Mitterrand government is centered upon the economic policies which include unpopular nationalization measures, and which have been unsuccessful in curbing unemployment.

Domestic Economy

With a strong popular mandate at the polls in 1981, the Mitterrand government fulfilled many of its campaign promises to expand the public sector in order to reduce unemployment and perceived inequities in income distribution. In retrospect, measures it adopted actually increased unemployment (now near 10.5% and rising), which the government had identified as France's major economic problem. The nationalization of companies, raising of the minimum wage, restrictions upon firing and layoffs, and increased

social service expenditures on the part of employers all had the effect of reducing capital investment in the economy which contributed to capital flight and loss of business confidence. Paradoxically, the Socialist government is now in the process of pursuing more classic conservative economic policies in order to revive the economy. While these practices have had noticible impact, the government has not benefitted from them politically. Many of their original supporters have drifted away while they have not picked up support from the right. One result of the economic turmoil of the past few years has been an increased understanding of the complex workings of a modern industrial economy on the part of unions and the working man. They have delinked wage increases from the cost-of-living increases. Their budget deficit is about 3.3% of total GNP.

Mitterrand's domestic economic policy emphasizes the need to strengthen France's high-technology industrial base. Laurent Fabius, who is now the Prime Minister, has been entrusted with the implementation of much of this program. France has a strong tradition of government guidance to both the nationalized and the private companies. One of the real dilemmas for the Socialist government is the reconciliation of its future-oriented programs with the need to preserve France's traditional industries. France is still putting most of its available resources into traditional industries such as steel and coal.

U.S.-French Relations

U.S.-French relations are good and are based on strong traditions and a variety of common interests and objectives. France is a major U.S. ally which participates in NATO, although it is not a member of the unified command structure. France has an effective military force which it continues to strengthen with modern weapons. However, the French tradition of a strong defense program has flattened out in the past few years, under their present administration. The French have recently launched a Polaris-type nuclear submarine and are working on a neutron weapon. They have now developed a rapid action force and updated their airborne divisions.

The French are actively engaged in a number of areas of the globe and our objectives and interests often coincide. In Africa and the Middle East we have worked together for stability and progress. French troops served in the MNF in Beirut, and French vessels participated in the minesweeping operations in the Red Sea. Their Mediterranean fleet works closely with ours.

Differences between the U.S. and France lie primarily in the trade area. At the Bonn Summit Mitterrand opposed setting an early date for a new GATT round, insisting on linkage between monetary reform and trade liberalization. Along with the U.S., France is a major agricultural producer, and has been behind many EC efforts to restrict the import of American farm products. French resistance to a new trade round stems largely from sensitivity about the questions of agricultural subsidies, an issue with profound political implications in France. Last year was the first time in a long time for the U.S. to have a deficit in the trade balance with France.

Science and Technology Issues

In addition to the Mitterrand government's emphasis on high-technology, there is a widespread feeling that France must keep abreast of new technologies to keep competitive in the future. The recent announcement of the Eureka project was in part prompted by SDI and the desire to "do something European" in response. A Le Monde headline the previous day talked of the Eureka project as an effort to "relaunch Europe". Eureka is not simply a Mitterrand response to SDI. Raymond Barre is totally behind the project and several editorialists in Chirac's camp have also supported it. Most French would agree that they have to protect their own independent research capability. There is uncertainty about if and how France will participate in cooperative big science projects with the U.S. The Europeans argue that they would be a more interesting and valuable partner for the U.S. if the European countries combine their individual expertise. The emphasis on site selection issues is hampering cooperative efforts in big science projects.

The competition between the Ariane program and NASA's space shuttle is another example of the French desire to demonstrate an independent capability in science and technology. The French take great pride in the achievement with Ariane. They view their subsidy of Ariane as reasonable because they contend the U.S. has been subsidizing the U.S. space launch capability for a long time.

AEROSPATIALE

Date of visit: May 30, 1985
Location: Les Mureaux, France

BACKGROUND

Organization and Capabilities.—The Societe Nationale Industrielle Aerospatiale (SNIAS) is a major source of aerospace production in France and in Europe. SNIAS is divided into four divisions: Space, Tactical Missiles, Helicopter, and Aircraft. The divisions produce launch vehicles, sounding rockets, satellites, aircraft, helicopters, tactical missiles, onboard electronics (data processing, telemetry and command, power supply), optical systems (laser reflectors, cameras, radiometers, lenses, imaging devices) and micromechanical parts and pyrotechnic devices and systems.

Overall Aerospatiale sales in 1984 were approximately 25.14BFFr (about $2.7B). Space and ballistic systems accounted for 15 percent of the 1984 sales and exports accounted for about 33 percent of overall sales. Overall Aerospatiale employment is 36,000 people, with about 1,250 in the space division. Aerospatiale has a number of affiliates producing light aircraft, including SFENA, which employs 3,000 people. Overseas, Aerospatiale has associates, mainly in the helicopter field, in the USA, Singapore, Brazil and Morocco.

Key Personnel.—Henri Matre became the President of SNIAS in 1984, succeeding General Jacques Mitterrand who retired and became President of the French aerospace industry association, GIFAS. Pierre Usunier is Head of the Space Division, and Pierre Madon is Head of the Civil Programs within the Space Division. Bernard DeLoffre is head of the Hermes program.

Space Projects.—Current Aerospatiale projects include the Ariane program, Meteosat, Intelsat V, Exosat, Marecks, TV-Sat/TDF-1, Telecom, Arabsat, SPOT, Samro. Aerospatiale is competing with another French company to become the prime contractor for the proposed Hermes program, a manned recoverable spaceflight system. Aerospatiale is the prime contractor for France's two strategic ballistic weapons systems: silo-based IRBM (SSBS) for the Air Force and the submarine-launched SLBM (MSBS) for the Navy. Past space projects include the Diamant and Europa launcher and many satellite programs, such as FR-1, Peole, Eole, D2-A, Starlette, Symphonie, COS-B, IUE.

DISCUSSION

The focus of discussion at Aerospatiale was on the status and future plans for the Ariane launch vehicle.

As industrial architect, Aerospatiale plays an essential part in the design, the coordination, and the technical management of the Ariane programs. Aerospatiale draws up the system level specifica-

tions and approves lower level specifications. The company does the system studies and manages the planning for the all-over development effort. It is responsible for configuration control and documentation.

The architect executes systems level testing (guidance and control, dynamic behavior, electrical chain validation, etc.) and manages the interfaces between the launcher and associated systems such as the checkout and launch facilities, software, etc. and handles studies necessary for each launch (mission analysis, sequencing, trajectory, flight data analysis . . .).

Stage contractor.—Aerospatiale leads a team of some 50 firms in European countries as the prime contractor for the first, second and third stages and the firings of Ariane 1 during the development phase. The company also developed Sylda, the dual launch system.

For the production phase Aerospatiale supplies the first and third stages and ensures at the same time the development of the first and third stages of the new versions Ariane 1, 3, and 4, as well as the strap on boosters, PAP (solid) and PAL (liquid), for Ariane 4. Major elements are manufactured by Aerospatiale, including the satellite/launcher liaison devices for single or dual launches, the main tanks for the first stage, and the pyrotechnical systems.

Characteristics and performances.—Ariane 1 is a three-stage launcher more than 47 m in height. It can place 1,750 kg in geostationary transfer orbit or more than a ton in geostationary orbit. The dual launch system, Sylda, enables simultaneous launch of two Thor Delta class satellites (from 600 kg to 1,020 kg in transfer orbit) under very competitive conditions. A stretched version of Sylda for Ariane 3 will enable dual payloads from 800 to 1,400 kg to be launched. This system, developed by Aerospatiale, gives more versatility to the launcher. Ariane 4, depending upon the version, will place from 2,000 kg to 4,200 kg in G.T.O. A new system, Spelda, will be used for multiple launches. The following table compares various launcher capabilities.

Launcher	Low Earth orbit (kg)	G.T.O. (kg)
Delta 3914	2,500	900
Ariane 1	4,850	1,750
Atlas Centaur	6,500	1,850
Ariane 3	5,900	2,580
Ariane 44L	8,000	4,200
Space Shuttle	30,000	[1] 7,500

[1] Theoretical value depending on upper stage used.

The first state is comprised of two identical high resistance steel tanks (15 CDV 6) and contains 140 tons of UDMH and N_2O_4. It is powered by 4 turbopump engines with 60 metric tons thrust each. Control in pitch, yaw, and roll is obtained by swiveling the mobile engines. Burn time is 140 seconds.

The second state uses 33 tons of the same propellants and a single engine of similar design, but adapted to operation in vacuum. Thrust is about 70 tons in vacuum. The engine is gimballed permitting control in pitch and yaw. Roll control is handled

by auxiliary jets. The light aluminum alloy tanks have a common bulkhead. Burn time is 140 seconds.

The third stage contains 8 metric tons of cryogenic propellants (liquid hydrogen and oxygen). It is powered by a low pressure turbopump engine (HM 7). Its thrust in vacuum is 6 metric tons. The engine is gimballed for pitch and yaw control, roll control being provided by auxiliary nozzles. The structure of the tank is in light alloys and has a common bulkhead. Burn time is 560 seconds.

Ariane 3 will be an Ariane 1 with two boosters, each with 7.4 tons of solid propellants attached to the first stage. The third stage will be lengthened to contain 10 tons of propellants instead of 8. Ariane 3 will place 2,580 kg in transfer obit. Ariane/Sylda will then ensure the launch of two STS–PAM–D class satellites.

Ariane 2, is, in reality, an Ariane 3 without the solid boosters. It will attain a performance of 2.175 kg in G.T.O.

The following step, Ariane 4, requires a considerable lengthened first stage, and maintains the upper stages of Ariane 2 and 3. The new first stage will have 220 tons of propellants in tanks 6 meters longer. A very flexible concept has been selected for Ariane 4 with solid and/or liquid boosters to enhance performance. Six Ariane 4 configurations offer mission capabilities from 2,000 to 4,200 kg in transfer orbit. Solid boosters will be those developed for Ariane 3, while the liquid boosters will be new, using Viking engines and conventional propellants, UDMH and N_2O_4.

The launcher will have a ngw dual launch capability, Spelda (Structure Porteuse Extreme pour Lancement Double Ariane). The fairings will increase in diameter to 4 meters.

The Ariane family will continue with an objective aiming at launching of very heavy loads (up to 15,000 kg): manned vehicles, space stations, etc. This step is foreseen during the 1990's. To achieve this a much larger cryogenic stage will be developed. Reusable stages and manned vehicles able to return to the launch base are foreseen, for example, the Hermes spacecraft already studied by Aerospatiale.

The Ariane family will give Europe access to all types of activities in space.

LAUNCH CAPABILITIES TO G.T.O.[1]

Launch configurations	Boosters	Payload (kg)
Ariane 1		1,750
Ariane 2		2,175
Ariane 3	2 solid	2,580
Ariane 40		1,900
Ariane 42P	2 solid	2,600
Ariane 44P	4 solid	3,000
Ariane 42L	2 liquid	3,200
Ariane 44LP	2 liquid + 2 solid	3,700
Ariane 44L	4 liquid	4,200

[1] Geostationary Transfer Orbit.

INTERNATIONAL ENERGY AGENCY

Date of visit: May 30, 1985
Location: International Energy Agency (IEA), Paris, France

SUMMARY

The International Energy Agency cautioned the delegation that we can expect a tighter oil and gas supply situation on a global scale with rising oil prices in the early Nineties. They expressed concern as to whether the United States can provide the proper nuclear/coal mix to meet increasing electrical demand in the Nineties. They also believe that the present gas market is sending wrong indicators such that when today's gas bubble is gone, they project that gas prices will rapidly escalate in the mid-Nineties.

The delegation representatives met with Mr. J. Wallace Hopkins, the Deputy Director of IEA, who provided an overall perspective on global energy issues. The delegation then discussed oil supply/price prospects, natural gas issues, alternative energy sources and the coal and nuclear mix in electricity generation with other members of the IEA staff (Hermann Franssen, Erik Sorenson, Eric Willis and John Jimison).

The delegation asked about an update of the 1982 "World Energy Outlook" report done by the IEA. Mr. Hopkins pointed out that forecasting from 1982 til now has not been so bad, compared to 1977 projections for the period 1977–1982. The IEA projects OECD use of oil to remain roughly flat, i.e., grow less than 1% per year for the next ten to fifteen years. As for the non-OECD nations outside the Warsaw Pact, they expect oil use to grow at 3% or greater. The IEA believes they have an improved statistical basis for these projections and for OECD production, including the fact that US off-shore prospects are looking considerably more pessimistic and that the North Sea supplies will turn downward in the early Nineties. The IEA staff noted that it generally takes nine to ten years to produce levels once reserves are firmly identified. The OPEC production has been reduced to 18.4 million barrels-a-day, with Algeria and Nigeria production down. The "willing capacity" is 25 million barrels-a-day with nominal capacity projected at 29–33 million barrels-a-day, so when the cushion goes there will be a price bump presumably in the early 1990's. Generally, in projecting OPEC levels, there is greatly improved expertise with significant economic input, since market characteristics are determining supply and demand in a refined fashion.

The IEA staff turned to their concerns about fossil and nuclear plant replacements in addition to new electrical generation requirements both in the US and worldwide. Since there are a greater number of coal plants on-line, the rate at which nuclear plants are added will be considerably greater than the rate of addition of

coal plants through the year 2000. The IEA sees increasing Canadian exports of electricity to the US as the only way to solve capacity requirements of the Nineties. In this context, there were a considerable number of questions from the delegation about improved use of coal. The IEA suggested that the US could learn from recently constructed Japanese coal plants, which IEA staff claims cost less than $1,000 per kilowatt in capital expenditures. This has not been confirmed by Committee staff and there is some skepticism about whether such costs could be below $1,300/kw. However, there was general agreement that although there was something to learn from the Japanese, it would be very difficult to achieve such cost levels in the US. Eric Willis recently visited Japan and reviewed their R&D programs, particularly synfuels. The Japanese government approach is to stress pilot plant development so as to provide options for heavily cost-shared industry demonstrations to prove out the economics of the more promising technologies. There was a brief discussion of the fact that in energy conservation the easy fixes have all been made and future conservation improvements will require much greater capital costs. As a result, such business decisions will require complicated trade offs.

The IEA staff expressed concern that the gas market is sending all the wrong indicators and that the temporary gas bubble does not provide the drilling incentives for tight gas and shale that will insure that such exploration be undertaken in the near future. They believe that there is a potentially bleak scenario in prospect and when the gas bubble disappears in the mid-Nineties, gas prices will rapidly escalate and force US customers to the unfortunate, near-term alternative to gas, i.e., oil.

Dr. Franssen, chief economist at the IEA, has done two recent studies, "North Sea Petroleum Developments in the Context of the Global Outlook for Oil and Natural Gas" and "OECD Oil and Natural Gas Production Outlook in the Context of Global Developments". Table 2 from the report depicts a scenario for world energy demand and supply to the year 2000. Table 3 demonstrates the fact that developing country demand is roughly a wash when compared with supply capacity of non-OPEC LDC's and net exports from the Eastern Bloc. Thus, the balance of OECD demand which cannot be supplied by the West must come from OPEC's increasing levels of production. The introductions from these two studies are included in Appendix E. The IEA staff has also just completed a report on the coal/nuclear mix for electricity (Mr. Jimison) and they promised to send this under separate cover. The IEA also recently completed a technology review, "The Clean Use of Coal," and the Executive Summary of that study is included as Appendix E. The Executive Summary of their recent "Energy Technology Policy" review is included as Appendix G.

TABLE 2.—SCENARIO FOR WORLD [1] ENERGY DEMAND AND SUPPLY, 1982–2000

[Mtoe]

	OECD	OXDC	OIDC	Total
1982				
Total primary energy demand	74.7	10.0	8.7	93.4
Oil	33.6	6.4	4.9	44.9
Natural gas	14.2	2.7	0.3	17.2
Coal	18.2	0.2	2.0	20.4
Other	8.7	0.7	1.6	11.0
Total primary energy production	55.6	30.4	5.0	91.0
Oil	15.5	26.1	0.7	42.3
Natural gas	13.3	3.0	0.4	16.7
Coal	18.2	0.5	2.3	21.0
Other	8.6	0.8	1.6	11.0
Total required exports (imports) [2]	(19.1)	20.4	(3.7)	(2.4)
Oil	(18.1)	19.7	(4.2)	(2.6)
Natural gas	(0.9)	0.3	0.1	(0.5)
Coal	0	0.3	0.3	0.6
Other	(0.1)	(0.1)	0	0
1990				
Total primary energy demand	87.5	13.6	11.9	113.0
Oil	34.8	8.6	6.9	50.3
Natural gas	16.4	3.3	1.0	20.7
Coal	21.8	0.3	2.3	24.4
Other	14.5	1.4	1.7	17.6
Total primary energy production	60–65	39.3–48.4	6.8–8.3	106.1–121.7
Oil	15–16	29.6–38.4	0.9–1.2	45.5–55.6
Natural gas	13–14	6.2–7.1	0.9–1.1	20.1–22.2
Coal	20–21	0.4–0.5	2.7–3.3	23.1–24.8
Other	14–15	1.1–1.4	2.3–2.7	17.4–19.1
Total required exports (imports) [2]	(27.5–22.5)	25.7–34.8	(5.1–3.6)	(6.9)–8.7
Oil	(19.8–18.8)	21.0–29.8	(6.0–5.7)	(4.8)–5.3
Natural gas	(3.4–2.4)	2.9–3.8	(0.1)–0.1	(0.6)–1.5
Coal	(1.8–0.8)	0.1–0.2	0.4–1.0	(1.3)–0.4
Other	(0.5–0.5)	(0.3)–0	0.6–1.0	(0.2)–1.5
2000				
Total primary energy demand	102.6	18.7	17.5	138.8
Oil	34.0	10.3	9.0	53.3
Natural gas	17.3	4.5	1.5	23.3
Coal	29.5	1.0	3.0	33.5
Other	21.7	2.9	4.0	28.6
Total primary energy production	70–80	42.0–53.9	12.2–15.6	124.2–149.5
Oil	12–15	30.8–39.3	0.9–1.3	43.7–55.6
Natural gas	11–14	6.9–8.7	1.1–1.3	19.0–24.0
Coal	28–30	0.8–1.0	5.2–7.3	34.0–38.3
Other	20–23	2.5–2.9	5.0–5.7	27.5–31.6
Total required exports (imports) [2]	(32.6–22.6)	23.3–35.2	(5.3–1.9)	14–6)–10.7
Oil	(22.0–19.0)	20.5–29.0	(8.1–7.7)	(9.6)–2.3
Natural gas	(6.3–3.3)	2.4–4.2	(0.4–0.2)	(4.3)–0.7
Coal	(1.5)–0.5	(0.2)–0	2.4–4.3	0.5–4.8
Other	(1.7)–1.3	(0.4)–0	1.0–1.7	1.1–3.0

[1] CPE countries and South Africa are not included.
[2] Total required exports (imports) includes net trade with centrally planned economies and South Africa, stock changes, and processing gains.

TABLE 3.—NON-COMMUNIST WORLD OIL DEMAND AND SUPPLY, 1983–2000

[Mbd]

	1984	1990	2000
Demand: [1]			
OECD [2]	34.7	33–35	33–35
Developing countries	11.5	14–15	17–20
Total	46.2	47–50	50–55
Supply capacity:			
OECD	17.6	16–17	12–14
Non-OPEC LDC's	8.0	8.8–10–0	9–11
CPE [3] net exports	1.9	1.0–1.5	0–0.5
OPEC [4]	18.4	29–33	27–33
Total	46.2	52.5–60.5	48–58–5
Stock changes	−0.6		

[1] Oil product demand.
[2] Including processing gains and NGL.
[3] CPE is centrally planned economies.
[4] For 1990 and 2000 the numbers represent production capacity.

THE EUROPEAN SPACE AGENCY (ESA)

Date of visit: May 30, 1985
Location: Paris, France

BACKGROUND

With the ratification of its Convention on October 30, 1980, the European Space Agency, which de facto came into being in May 1975, acquired its legal existence. The Agency groups in a single body the complete range of European space activities previously conducted by ESRO and ELDO in their respective fields of satellite development and launcher construction.

The ten founder members of ESA are Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Ireland, although not a member of the previous space organizations, also signed the ESA Convention in December 1975 and thus is now a full member of the Agency. Three other states are closely associated with the Agency: Austria is an associate member, with the status defined in the Convention; Canada has an agreement for close cooperation; Norway has observer status but negotiations are under way for this state to acquire associate membership.

The Agency's purpose, as described in its convention, is to provide for and to promote, for exclusively peaceful purposes, cooperation among European states in space research and technology, and their space applications, with a view to their being used for scientific purposes and for space applications systems. To fulfill its mission the Agency:

(a) elaborates and implements a long-term space policy, recommends space policy, recommends space objectives to its member States, concerts the policies of the member States with respect to other national and international organizations and institutions;

(b) elaborates and implements activities and programs in the space field;

(c) coordinates the European space program and national programs, integrating the latter progressively and as completely as possible into the European space program, in particular, as regards the development of applications satellites;

(d) elaborates and implements the industrial policy appropriate to its program, and recommends a coherent industrial policy to the Member states.

Organization and Function

The Agency's policy-making body is the ESA council composed of representatives of the member States. The council takes decisions on the policy to be followed by the Agency, and on scientific, tech-

nical, administrative, and financial matters, each state having one vote (but none in the case of an optional program in which it is not participating). The level of the Agency's resources for its mandatory activities is determined for a period of five years in advance by a unanimous decision of all member States. Other decisions are taken on a simple, or two-thirds, majority vote.

The Convention established a science program committee, to which are referred matters relating to the mandatory science program, the Committee is authorized to make decisions relating to that program. The council may also establish such other subordinate bodies as may be necessary for the purposes of the Agency. Delegations from the Member States sit on all such committees and program boards.

The chief executive and legal representative of the Agency is the Director General, who is appointed by the Council for a defined period. He is assisted by six directors who are responsible for the following directorates: Administration, Applications Programs, Spacecraft Operations, Scientific Programs, Space Transportation Systems, and the Technical Directorate.

DISCUSSION

Space Science

In the coming decades ESA intends to develop its efforts in keeping and increasing the European space science community's role at the forefront of scientific research on the world scale. To this end, ESA has developed a long-term plan for missions to be launched in the mid-to late-nineties and the early years of the next century.

It is founded on four major cornerstones. Of the four cornerstones, two are in the solar system sciences: planetary science and solar terrestrial physics. The other two are in astronomy, in the X-ray and submillimeter domains (X-ray spectroscopy and heterodyne spectroscopy).

The four cornerstones are:

The Solar Terrestrial Physics program (STP).—The STP program builds on the extensive European experience in solar, heliospheric and space plasma physics. It will attack the outstanding scientific problems in these fields in a unified and well-coordinated approach.

A Mission to Primordial Bodies including Return of Pristine Materials.—Within planetary exploration, this is an area where Europe could take the lead, following on the Giotto mission: the return of primordial material from primitive bodies, namely from asteroids and comets, constitutes a major theme in future planetary science.

A High Throughput X-Ray Mission for Spectroscopic Studies between 0.1-20 KeV.—An observatory comprising multiple telescopes will provide the required sensitivity to perform detailed spectral diagnostics of many classes of objects with low surface brightness. This is particularly important for studying the evolution of the large and small scale structures of the universe.

A High Throughput Heterodyne Spectroscopy Mission.—The submillimeter domain is the last remaining gap in the electromagnetic spectrum left unexplored. Apart from the continuum radiation from cosmic dust, this range also contains a large number of very

important atomic and molecular transitions which provide a direct probe for studying the physics and chemistry of the cool universe in the range 3 to 100 degrees Kelvin.

Following these four cornerstones, on which the future program of ESA is based in the next 15 to 20 years, it is already possible to identify beyond the horizon other major thrusts: these are the Solar Probe and the Heliosynchronous Out-of-Ecliptic Mission in solar terrestrial physics, the Mars Rover in the planetary area, and, in astronomy, two-dimensional interferometry for high spatial resolution in the visible, IR and mm range.

On a smaller scale, a number of conventional medium-size projects, will be carried out in the same time frame. They include projects already approved and about five other new projects.

A number of still smaller projects are included in the program. They respond to the need for frequent flight opportunities, for quick reaction to missions of opportunity and for minor participation in projects of other Agencies. Prominent in this class is a program of utilization of retrievable platforms such as the Eureca platform, suitably modified to meet the requirements of astronomical and solar-physics payloads.

Also included in the program is the development of the technologies which are needed for the cornerstones and future missions.

The hardware development phase of two deep-space missions is nearing completion:

Giotto.—This spacecraft will take a "close-up" look at comet Halley which it will fly-by at a distance of 500 km from the nucleus in March 1986.

Ulysses.—This cooperative ESA/NASA mission will explore for the first time the third dimension of the solar system by flying high over the poles of the sun.

The development of two further astronomical facilities is well under way:

Hubble Space Telescope.—ESA's contribution to this NASA project consists of the Faint Object Camera, the solar arrays and support to the Space Telescope Institute in the USA as well as the European Coordinating Facility located at the European Southern Observatory, ESO, Garching, West Germany.

Hipparcos.—The scientific goals of the space astrometry mission Hipparcos are the accurate measurement of the positions, proper motions and trignometric parallaxes of about 100,000 selected stars. Hipparcos will provide a ten-fold improvement in the precision of existing observations.

Finally, early technical work is in progress in preparation for:

ISO.—The Infra-red Space Observatory will be offering high-sensitivity observing facilities for a large region of the electro-magnetic spectrum which is relatively unexplored.

Earth Observations

ESA's plans in the Earth Observation Field over the coming decade cover both scientific and applications aspects in four main areas, namely:

Ocean and ice observations, with a program following on to ERS-1 which will comprise both research and development as well as operational elements.

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Land observations, with a mission designed for all-weather microwave and optical observations.

Meteorology, with the continuation of European involvement in geostationary satellites for meteorological applications through the implementation of the Meteosat Operational Program, and the development of a second-generation Meteosat system.

Missions initially of scientific interest which in some cases lead to applications in the field of solid-earth physics which will exploit very precise measurement techniques for Earth-oriented research. Other missions will address the problems of the upper atmosphere and climatology.

ERS-1 is expected to be the forerunner of a series of European remote sensing satellites to become operational in the 1990's. Its mission objectives, of both an economic and scientific nature, are as follows:

—to establish, develop and exploit the coastal ocean and ice applications of remote sensing data with a view to improving our knowledge of ocean parameters and sea state conditions. These applications are particularly important due to the increasing development of coastal and off-shore activities and the adoption of the 200 nautical mile economic zone;

—to obtain high-resolution images of land surfaces in all weather conditions, which will be possible thanks to the on-board Synthetic Aperture Radar (SAR);

—to increase the scientific understanding of coastal zones and global ocean processes which, together with the monitoring of polar regions will provide a major contribution to the World Climate Research Program.

Priority in the payload has been given to a comprehensive set of radar instruments designed to observe the surface wind and wave structure over the oceans.

Ariane

ESA has established the following future requirements:

—the ability to launch satellites of ever-increasing size and mass,

—a reduction in launch costs compared with Ariane 4,

—reliability equal to that of the Shuttle.

These are the development program criteria for the European launcher, Ariane 5, which will form part of ESA's activities over the next fifteen years, with a first operational launch scheduled in 1995.

Ariane 5 is a three-stage launcher consisting of a lower composite comprising two strap-on solid boosters and a main stage, and an upper section adaptable to each mission.

The strap-on boosters, which are 25m long and have a diameter of 3.10m, each carry 170 tons of solid propellant and each develop a thrust of 500 tons for 2 minutes

The main stage is a cryogenic one, powered by a single engine (HM 60); it contains 120 tons of propellant and measures 5.40 m in diameter with a total length of 25 m. Its engine delivers a thrust of 100 tons for about 9 minutes.

Two different versions of the upper composite are planned for automatic missions: one with cryogenic propulsion derived from the third stage of Ariane 3 for placing in geostationary transfer orbit

payloads with a mass of up to 8 tons, the other with storable-propellant propulsion for placing in transfer orbit payloads with a mass of up to 5.3 tons.

A set of fairings and adaptors for payloads of different sizes is planned to meet user requirements. The usable diameter within the fairing is 4.55 m (as for the Shuttle) with a usable length of between 4m and 10.5 m. Bearing structures of a design similar to that planned for Ariane 4 will allow launches of two and even three satellites simultaneously.

Finally, the upper composite planned for automatic missions may be replaced by a "spaceplane", such as Hermes, for the manned missions that may be expected in connection with the space station program towards the end of the century, thus enabling Europe to acquire autonomy in all aspects of space transportation.

Manned and Retrievable Systems

Through existing or planned projects such as Spacelab, Eureca and the Space Station, ESA hopes to lead its Member States into the new era of the discovery and commercialization of space.

Europe's eventual goal is an autonomous Space Station which will provide European scientists and industrialists with a permanent platform for research and the processing of key materials. However, to attain this lofty goal, a gradual evolution is envisaged.

Immediately, the use of Spacelab will give ESA Member States basic experience in the optimum use of a manned space station. Applications in the fields of Earth Observations, Astronomy, Plasma Physics and Microgravity are foreseen as well as the use of Spacelab as a test bed for technology and system development.

The design and development of Eureca is now under way. It will exhibit both the qualities of Spacelab and unmanned conventional satellites. Any disturbing influences introduced by Man are avoided while still retaining the possibility of manned intervention during its Shuttle launch. This unmanned retrievable free-flyer ensures a 10^{-5}g environment for the duration of the mission which is nominally six months. While being an extremely useful tool in its own right for scientific and commercial use, Eureca represents a bridge between Spacelab and Space Station. In particular, it will be used to develop the rendez-vous and docking techniques so essential to Space Station operation. Its first flight is scheduled for early-1988 with retrieval some six months later. Launches of this reusable system will take place every 18 months to two years.

A possible European participation in the US space station could be a pressurized module for housing men or experiments, a platform for carrying unpressurized payloads, and a resources module. The module and platform could be used either attached to the Space Station or in a free-flying mode. A polar orbit version of the free-flyer has a particular attraction for science and remote sensing applications.

ESA entered the manned space-flight field with the successful flight of Spacelab in the Orbiter Columbia over the period 28 November to 8 December 1983. As discussed earlier the agreed follow-on to Spacelab is the retrievable carrier Eureca. Spacelab and Eureca represent solid investments for the future. Europe can build on the engineering and technical experience gained through

its involvement with these two programs. Spacelab, both module and pallet, lends itself to being developed as an essential part of a permanently manned Space Station. The basic Eureca principles can lead to an unmanned platform which can be visited by Shuttle astronauts from time to time when free-flying or which can be serviced at the Space Station when docked.

A major on-going activity is the Columbus preparatory program for Space Station participation. The Phase B will be completed by the end of 1986 and the phase C/D will commence in April 1987. The Space Station operational phase (E) will start in 1992/93 and continue until the end of the century and beyond.

The following table presents a summary of the programmes underway in the Directorate of Space Transportation Systems.

Programme	Main elements	Duration
Spacelab Utilisation	Spacelab and Experiments	1983–1993
Spacelab FOP	Spacelab Flight Unit, IPS and Ground Support	1980–1985
Eureca (development and first flight)	Eureca Carrier + Core Facilities	1984–1988
Microgravity Phase 1	Biorack, Sled (flight), Fluid Physics Module. Opportunities on Spacelab and Texus.	1982–1985
Microgravity Phase 2	Anthrorack, Fluid Physics Double Rack. Opportunities on Spacelab, Shuttle, Texus.	1985–1988
Long Term Preparatory Programme	Ariane 5, Pressurised Module, Platform Elements, Advanced Technology.	1982–1985
Columbus Preparatory Programme	Pressurised Modules, Platform Elements, Resources Module, Service Module, Space Station Ground Segment, Demonstration Missions.	1985–1986

MEETING WITH U.S. DELEGATION TO THE O.E.C.D.

Date of visit: May 30, 1985
Location: Paris, France

The Organization for Economic Cooperation and Development (O.E.C.D.) which has a membership that includes the countries of Western Europe plus Japan and the United States is headquartered in Paris. Members of the Congressional delegation met with the chief of the U.S. Delegation to the O.E.C.D. Ambassador Edward J. Stretor and his staff.

Trade Negotiations

Ambassador Stretor noted that his initial concern after coming to his present post was to take a careful look at the O.E.C.D. and determine how the U.S. most effectively could pursue its goals. A number of goals can be pursued through the O.E.C.D. An important item of unfinished business is the multi-fiber agreement. In agriculture it now appears that the U.S. is on a collision course with the Europeans, chiefly because many countries in Europe will not place any limits on domestic production. On the other hand, in the services area, all parties now appear to be in good shape to begin negotiations.

Europe maintains high trade barriers against the import of U.S. high technology. This is particularly notable in telecommunications where each national ministry for post and telecommunications have a strong tendency to buy domestically designed and produced equipment. For example, in France the approval of telecommunications systems takes one year, is very detailed, and each year one half of all foreign applications are turned down. The U.S. is trying to do something about this via the GATT negotiations. The Europeans are highly concerned that if they open their domestic markets, Japanese industry will come in very strongly.

Europe has been in a trough with respect to economic growth. It is not at all like Japan—there is not a good pattern of economic growth. This has implications for Europe's ability to carry its share of the common defense burden. To permit a resumption of growth the U.S. has urged extensive structural adjustments in the areas of education, taxation, and investment policy. There is a great deal of inertia in many of the continental societies, and they are only now taking the initial steps to adjust to the new needs.

European Science and Technology

In the science and technology sphere the European countries must be better able to adjust to changes. One indication of the ambivalence in Europe with respect to the changing technological environment is a recent opinion survey which showed that the public in some countries have little interest in word processing, while

others have a high degree of interest. The American initiative to begin research on the Strategic Defense Initiative (SDI) has triggered a great interest in Europe in science and technology generally. The French proposed response in the form of the Eureka Project was originally met with some scepticism from England and some other countries. But it is receiving a growing amount of attention in Europe.

In general, Europe is at a crossroads in the development of its science and technology capability. Up to now they have not had the necessary economy of scale within each country or even within each country. That is why Project Eureka is so important. It could lead to a proliferation of consortia, patterned on the successful Airbus project, which may have the right economy of scale to succeed. The European tradition of erecting national barriers rather than opening up their markets and their economies must be overcome.

O.E.C.D. Science Indicators Program

The progress of the O.E.C.D. Science Indicators program was discussed with Dr. Allison J. Young, an economist from Great Britain who is the Acting Director of the program. The 1984 Science Indicators report, covering statistical series about both science and technology in the member countries over the last 10 years, was well received and is now out of print. The next O.E.C.D. Science Indicators report is due in 1986.

The O.E.C.D. currently has a staff of 12 working on the development and compilation of the indicators. This development effort is being done by the O.E.C.D. staff in close cooperation with the member nations, and outside consultants are not being used due to budget constraints. The focus now is on building a data base in the patent area. In this connection, the O.E.C.D. staff is concerned about the reduced effort by the U.S. Patent and Trademark Office to disminate statistics about U.S. patents. Particularly useful has been information about patents issued to the U.S. to applicants from the other O.E.C.D. member countries.

In addition to the main science indicators reports, the O.E.C.D. group also issues interim reports on "Recent Results". A copy of the most recent interim report was made available to the delegation, and is in the Committee's files. Dr. Young expressed the interest of the O.E.C.D. in the Committee's Science Policy Study, and offered to make available any information in the O.E.C.D. data base to the Science Policy Task Force.

Meeting With U.S. Agricultural Attaché to France

Thursday, May 30, Congressman Volkmer met with Dr. Besa Kotati, United States Agricultural Attaché to France, concerning agricultural programs of the European Community and the possible changes in these programs in the future. Emphasis was on wheat production and its exports, feed grains, dairy and livestock production.

Dr. Kotati emphasized that there is a great deal of criticism within the European community over the escalating costs of agricultural subsidies. He did not believe the French would agree to

any reduction in production of wheat if that is proposed in September. He emphasized that the French had reduced their dairy production by about three percent while the West Germans had reduced dairy production by nearly eight percent.

He also noted that the European agricultural ministers were anxious about what Secretary of Agriculture John Block would say at the Food Council meeting.

MISSION OF INFORMATION—FRANCE

Date of visit: May 30, 1985
Location: Paris, France

SUMMARY

Members of the delegation visited the French Mission of Information for discussions about the problem of computer crime in France.

DISCUSSION

The Mission of Information is an intergovernment agency attached to the Ministry of Telecommunications. One department of this agency reviews all government computer and software acquisitions for compliance with approved, standardized procedures. Another department studies the effects of computers on society. Among the responsibilities of the latter is examination of the problems associated with the improper use of computers. The reason for this assignment of responsibility was that only an intergovernmental agency could deal with such a cross-cutting issue.

The first difficulty encountered by the Mission of Information investigators was that few reliable statistics on the extent and cost of computer crime existed and few cases of illegal computer use were documented. They found much the same condition in other countries, including the U.S. At the present time, the Ministry of Justice is studying how to collect better statistics. A further problem was that manufacturers have little interest in improving the security of their systems because the costs of doing so would hurt their competitive positions. Furthermore, users do not demand such improvements because they do not perceive a real threat.

A project is underway by the Commission for Revision of the Penal Code to determine the need for a new law to better define computer crime. Since the old code dates from Napoleonic times, many in France feel that major changes are needed in order to conform to the modern world. One such area is the technology represented by computers. The Commission hopes to have a draft law before the Parliament before the end of 1985.

The basic philosophy of such a new law would include the following:

—definitions that are left non-specific in order to allow technology to move forward without making the law obsolete;
—a presumption that new law is needed since information has no standing in existing law and therefore crimes involving theft or destruction of information cannot be prosecuted. (The only intangibles with standing are copyrights and patents.)

—a breakdown of computer crime into three categories: unauthorized access; destruction of a computer system or data contained in one; use of a computer to commit a crime.

The Mission of Information is currently conducting a feasibility study of a computer crime data bank. It is interested in developing a methodology for analyzing each case, both from a legal aspect and a technical aspect. This would include, for example, a profile of the perpetrator.

Another activity being pursued by the Mission of Information is a demonstration of good computer security at a selected public sector data center to show others in government and the private sector what is possible. The agency chosen for this pilot is the Ministry of the Sea. A plan for implementing the security improvements will be ready by October, and the center will be operating by the end of 1986.

THIRTY-SIXTH SALON INTERNATIONAL DE L'AERONAUTIQUE ET DE L'SPACE

Date of visit: May 31–June 2, 1985
Location: Le Bourget Airport, Paris, France

SUMMARY

The 36th Paris Air Show once again vividly demonstrated the growing international character and competitiveness of the aerospace industry. Over 1000 exhibitors from 33 countries filled 550,000 square feet of covered exhibit space and 1.3 million square feet of outdoor static display area, exhibited some 250 aircraft, and flew about 40 of these in daily demonstrations.

Among the aircraft appearing for the first time at Paris were two from the Soviet Union, the Antonov AN–124 heavy-lift prototype transport and the Kamov Ka–32 civil helicopter. Other new aircraft included the Italian/Brazilian AMX fighter, the Israel Aircraft Astra business jet, the Dassault-Breguet Falcon 900 business transport and the French Mirage 4P nuclear attack aircraft.

Several countries organized their own national pavilions at the show. The U.S. again sponsored a major exhibit representing 95 companies aimed at selling U.S. aerospace products. In 1983, a similar effort resulted in reported sales of $130 million. A total of 66 companies from the U.K. aerospace industry were brought together by the Society of British Aerospace Companies, organizers of the Farnborough Air Show. Other countries with national pavillions were Canada, Israel, Italy, West Germany and the Soviet Union.

As in previous Paris Air shows, NASA was a major participant. The themes this year were international cooperation in the space station and marketing of shuttle launch services.

DISCUSSION

For many years the United States has enjoyed the benefits of a preeminent position in aerospace. These have included major contributions to national security and economic well-being. For example, in 1984 the U.S. experienced a net positive contribution to its balance of trade from the aerospace sector of over $10 billion, second only to agricultural products. Furthermore, total employment among major aerospace companies was over one million.

These results have depended on a number of factors including a steady flow of innovative aeronautical and space research, a healthy American industry and favorable conditions for U.S. Exports. Since the Science and Technology Committee has responsibility for authorizing the programs of NASA, its decisions have a major bearing on the ultimate success of this important industry. To assure that these decisions are made correctly, its Members

must have a full understanding of the programs of potential competitors.

Since its inception in 1908, the Paris Air Show, a biennial event organized by Groupment des Industries Francaises Aeronautic et Spatiales, continues its traditional role as the world's foremost exhibition for the international aerospace industry. Truly international in character, the Paris Air Show provides a technical and commercial forum featuring the lastest and most sophisticated aerospace technological equipment and services for a constantly growing international audience. Much international trading is initiated at the Paris Air Show.

Everything used by the world aerospace industry from tiny rivets to massive jet engines, from micro-chips to what the Soviets claim is the largest aircraft in the world, was on display at the 36th Salon. The Soviet aircraft, the Antonov An-124, has a wingspan 12 feet longer than the U.S. C-5 cargo aircraft, but a fuselage that is 7 feet shorter.

Other features of the Soviet display were a Tupolev TU-154M, a more powerful version of the well-known TU-154 airliner, the Kamov KA-32 helicopter, the Mil Mi-26 heavy lift helicopter and the Yakolev Yak-42 commuter airliner. Among the exhibits in the Soviet national pavilion was an An-124 high by-pass ratio turbofan engine.

Despite the size of its exhibit, the Soviet Union was not the only representative of the Eastern bloc. Hungary, Poland, Romania, Czechoslovakia and Yugoslavia also attended this year's show. Of these, Romania had the largest presence, showing the two helicopters it manufactures under license from Aerospatiale of France, the IAR-330 Puma and IAR-317 Aloyette III. Sales of these helicopters, particularly in Africa, have been good in recent years. In addition, Romania exhibited a tandem two-seat turboprop trainer (IAR-825TP), a turboprop agricultural aircraft (JAR-827TP), a two-seat light aircraft (JAR-28MA) and a previously unknown two-seat turbojet trainer for advanced flight and weapons training.

Yugoslavia's aerospace concern, SOKO, demonstrated the G-4 super Galeb tandem two-seat jet trainer and light attack aircraft that first flew in 1978. Also featured was the J-22, a ground attack and close air support fighter powered by two license-manufactured Rolls-Royce Viper turbojets. Poland exhibited a modern single-engine agricultural aircraft (PZL M-18 Dromader).

The number of major U.S. aerospace firms at the show was impressive; however, the range of aircraft they exhibited was not. A reason for this is that there were practically no new aircraft since the last show. An exception was a full-scale mock-up of Grumman's X-29 forward-swept-wing experimental fighter developed under contract to DARPA.

The purpose of the X-29 program is to evaluate the unique advantages offered by the forward swept wing, a configuration that has been used sparingly until now because of the large weight penalties exacted in overcoming flight load stresses. Grumman's innovative use of composite wing covers incorporating aeroelastic tailoring of wing bending motions counteracts these stresses without imposing the weight penalty.

The X-29 also helps advance the state-of-the-art in aerodynamics, flight control, and aircraft structure. For example, the trailing edge of the wing incorporates a computer controlled discrete variable camber device that alters the wing shape in flight as a function of changing conditions. In addition to functioning as an aileron, this device increases maneuverability and reduces drag across the entire flight envelope. The result is a constantly optimum wing shape—a significant advantage in combat aircraft.

The X-29 digital flight control system translates the pilot's commands into control surface motions. It allows the use of canards mounted forward of the wings in place of the horizontal tail normally mounted at the rear of an aircraft, and it adjusts the angle made by the canards with the airflow some 40 times a second. Because the canards make the aircraft aerodynamically unstable, the X-29 is extremely agile.

After a three-year development period, the X-29 flight test program began with a successful first flight on December 14, 1984, at NASA Dryden Flight Research Facility, Edwards Air Force Base, California. Testing through 1987 will evaluate handling qualities, performance, and system integrity at both subsonic and supersonic speeds. In addition, alternate control laws, ultra-high angle-of-attack characteristics, and other advanced technolgies can be pursued in an expanded flight test program.

General Dynamics flew the "C" version of its F-16 air-to-air fighter. Northrop had planned to show a prototype of its F-20, but the aircraft crashed in Goose Bay, Labrador on May 14, while practicing for Paris. A mockup of the plane was displayed instead. Hughes withdrew its helicopters from the show when the Army refused to support flying the AH-64 Apache either in a self-ferry mode or in a C-141. Boeing withdrew its two CH-470's, leaving only the Sikorsky UH-60 Blackhawk to represent U.S. military helicopters.

Other aircraft from North America included the Cessna Citation 3 and Caravan 1, and the Dash Commuter from deHaviland of Canda. Lockheed brought its new High Technology Test Bed as well as the airborne early warning and control variant of its P-3 Orion. Lockheed is attempting to compete its P-3 variant for the French Air Force's program for four airborne early warning aircraft. All signs suggest this effort is fruitless, as it is generally accepted in French aerospace circles that if the necessary financing is available, the Boeing E-3A Sentry will be procured to meet this long-standing requirement.

Fifteen Western European countries appeared at the show this year, but they presented few new aircraft. France, the host country, exhibited only one new military aircraft which is in fact a refurbished and updated version of a 20-year old design. This aircraft, designated the Mirage 4P, is the first of 18 Mirage 4A bombers that will be modified with a new avionics suite and radar for the low-level penetration mission. In addition, Dassault-Breguet displayed its new Falcon 900 business jet.

Italy's Agusta Group contributed the only totally new military helicopter design, the A-129 Mangusta, which made its first public flight at Le Bourget. In addition to a number of Middle Eastern and European sales, Agusta is pushing the A-129 in Great Britain.

The British army has a requirement for between 75 and 125 attack helicopters. Agusta also hopes to sell the A-129 to both France and West Germany, as a low-cost alternative to the PAH-2/HAC-HAP program being jointly developed by those countries.

Another Italian first was the premier of the AMX tactical fighter, being jointly developed by Italy's Aeritalia and Aermacchi and Brazil's Embraer. The AMX was originally to have been shown at last year's Farnborough Air Show, but the loss of the prototype in May 1984 precluded this. The Paris Air Show marked that aircraft's first public appearance.

Two new trainer designs were brought to Paris by two of Europe's smaller countries. Switzerland's Pilatus exhibited its PC-9 turboprop trainer, which recently lost out in the competition to supply a new basic trainer to Britain's Royal Air Force. Valmet of Finland brought its L-80TP turboprop trainer, derived from the company's piston-engine L-70 Miltrainer; both of these aircraft were shown in the static park and in flight. Another turboprop trainer, the British Hunting Firecracker, also came to the show this year for the first time.

Although numerically still constituting only a small minority, developing countries had a significant showing at Le Bourget for the first time. Their presence exemplifies the emergence of new aerospace industries in smaller countries. At least four of these countries brought aircraft of their own design to the show.

The most interesting of these aircraft was the Argentinian IA-63 Pampa, a single-engine jet trainer developed by Fabrica Militar de Aviones with technical assistance from West Germany's Dornier.

Other third-world countries at the air show were Chile and Morocco. Hinduston Aerospace Ltd. of India brought a light civil helicopter (LTT-34), powered by a piston engine and designed with technical assistance from West Germany's MBB. This development is doubtless a sign of things to come. The People's Republic of China also exhibited.

Even though several new aircraft were exhibited at the show for the first time, the aircraft of interest to most visitors are still on the drawing board and many of them are European cooperative ventures.

Among these is the European Fighter Aircraft (EFA). Though only three years old, this program is a prime example of the difficulties of international cooperation. Five countries—Great Britain, France, West Germany, Italy, and Spain—will need a new tactical fighter to replace part of their present combat fleets by the mid-1990s. These five decided to study the feasibility of developing a common aircraft to meet their requirements. In a remarkably short time, the five countries concluded that this was indeed possible, and the air staffs concerned went as far as agreeing on a basic specification suitable to them all. Thus, with seemingly disarming ease, they overcome what is generally considered the major stumbling block in cooperative programs: meeting, with a single aircraft, the requirements of several armed forces.

Little seems to have advanced since this stage was reached in 1984. Paradoxically, it was after the major hurdle was cleared that seemingly minor problems grew to the point where they now menace the program's progress. From an industrial point of view,

France's Dassault is insisting on a major share of the EFA, possibly including the main contractorship. This is being hotly contested by British Aerospace, which considers itself just as deserving. The three members of the Panavia consortium (Britain, Germany, and Italy) would like to develop the EFA by using the existing, although enlarged, Panavia/Turbo-Union structure, but France steadfastly opposes this. Dassault, which is developing its own EFA demonstrator—dubbed ACX and recently baptised "Rafale"—seems to be pushing for continuing this project, which is being funded by the French Ministry of Defense, as a national, or possibly bilateral, program.

This would allow France, which prefers a lighter aircraft powered by two SNECMA M–88s also being developed with government funding, to go it alone, leaving the other three countries to continue developing a new fighter around the British Aerospace EAP demonstrator. This aircraft, partially funded by the British government, is envisioned by some British observers as being the logical follow-on to the Tornado within the Panavia consortium, and offers the added attraction of possibly being powered by improved variants of the RB–199 engine used in the Tornado.

Furthermore, there are differences revolving around the time frame for the EFA. The British once identified a requirement to replace its Jaguars around 1990. But the idea of a cooperative venture brought with it a delay in that schedule, which has further slipped to the mid-'90s. A program must be begun soon in order to meet that date. France, on the other hand, is not in as much of a hurry. It already has its Mirage 2000 to augment its forces and is counting on exporting it well into the 1990s. Any EFA produced in that time frame would only be unwanted competition.

Whatever the future may hold for the EFA, Le Bourget should mark a watershed in its development, and talks between government authorities and manufacturers from the five countries during the show will no doubt influence the project's future.

Another major international program, announced at the show, is a joint venture to develop an advanced turboprop concept. General Electric and SNECMA of France signed a memorandum of understanding, assinging to SNECMA a 35-percent share in G.E.'s Unducted Fan engine program. According to the memorandum, SNECMA will participate in the design and component testing, scheduled to start in mid-1986. A decision on full-scale development is expected in 1987.

An initial UDF concept verification effort was initiated in 1983 with the support of the National Aeronautics and Space Administration. The UDF is designed for initial application on subsonic commercial aircraft followed by use later on military aircraft. The UDF is expected to provide fuel savings of 40 to 60 percent over current turbofan engines, or savings of 20 to 25 percent over equivalent technology future turbofans. The engine's unique design includes counter-rotating, variable pitch, unducted fan blades driven directly, without a gearbox, by two counter-rotating turbines.

A NASA-sponsored proof-of-concept engine in the 25,000 pound thrust (111 kN) class is scheduled for ground testing at General Electric's Peebles, Ohio, facility in August. The proof-of-concept engine will use a modified General Electric F404 fighter engine gas

generator. Joint General Electric/Boeing flight testing on a Boeing 727 is scheduled to begin in the summer of 1986.

Finally, despite the return en force of the Soviet Union and the U.S., this year's Paris Air Show will probably be remembered for its progress in international cooperation and for its new third-world exhibits as much as for the presence of U.S. and Soviet aircraft.

In fact the most vivid impression gained by Members of the Committee was the changing character of the world aerospace market. No longer is the United States, along with a handful of others, the sole supplier. Many other countries see high technology, in general, and aerospace, in particular, as a means to enhance their economic standing. For this reason they are rapidly catching up in their ability to produce conventional and even highly sophisticated items. The U.S. can no longer maintain its position by emphasizing competition with the Airbus and the Ariane launcher. Rather it will be necessary to invest heavily in break-through technologies, so as to render competitive products obsolete. Examples of such technology are the space station, hypersonic air breathing propulsion and the advanced turbo-prop.

TRAIN A GRANDE VITESSE (TGV)

Date of visit: June 3, 1985
Location: Paris to Lyon, France

SUMMARY

Members of the delegation rode the TGV from Paris to Lyon and received briefings on the operation of this high-speed, state-of-the-art rail technology.

Since September 1981, the fastest trains in the world have been running in revenue service in France at speeds of 270 km/h (168 mph) on a new line which has been completely integrated into the existing network in the Southeast of France. This achievement is called the TGV Paris-South East because the new high speed trains (TGV) serve all the large towns in the Southeast of France, i.e., 40% of the population of France. The excellent results obtained, both from the technical and the financial and commercial points of view, have led the French authorities to consider applying the TGV to other regions of France, in particular to the West and the Southwest; hence a new project is underway called "TGV Atlantic".

DISCUSSION

The Paris-Lyon Mediterranean axis is one of the main arteries of the French national railway network, catering to 40 percent of France's population. Increasing demand along this line led the French to establish a new line reserved exclusively for passenger services linking Paris and Lyon, and to design a high-speed train using modern rolling stock. To assure profitability, the new line had to be fully integrated within the existing network so that the high-speed trains would be able to continue their route over present infrastructure to the main cities of southeastern France.

The TGV rolling stock is aerodynamically designed with a streamlined nose and reduced cross-section for better air penetration. A typical trainset consists of two power cars, bracketting eight air-conditioned coaches with a total seating capacity of 386 (111 in first class and 275 in second class).

The basic design is an articulated trainset, with a common truck under the bodyframe of two adjacent coaches. This design approach reduces both the mass and cost of the train and makes for greater stability at high speeds.

The two power cars have a total of 12 traction motors with a combined output of 8,500 hp. This allows the TGV to climb gradients up to 3.5 percent, comparable to mountain roads, at full speed.

With its 270 km/hr running speed on the high-speed portion, between Paris and Lyon, TGV travel time is considerably reduced from previous levels. Currently the travel time from Paris to Marseilles is 4 hours 50 minutes, a savings of 1 hour 45 minutes. The

delegation's trip from Paris to Lyon, a distance of over 300 miles, was exactly 2 hours.

The high-speed line is electrified with industrial current at 25 kv. It has a reinforced, but conventional roadbed with continuous welded rail, concrete ties, very thick ballast, switches that can be taken at high speed and long radius turns. There are no tunnels, or grade crossings.

Train safety is assured by an entirely new system which makes no more use of conventional signals usually set up along the tracks. All information relating to train operation is transmitted through track circuits, picked up by sensors on the power cars, and displayed in the driver's cab itself. Consequently, the driver is informed at all times of the speed he has to maintain and his reactions are checked by an automatic driver's vigilance control device. In addition, radio-telephone equipment enables him to stay in constant communication with the central traffic control station.

Construction work on the new line began in 1976. Half of it opened in September 1981; the full line, in September 1983. Since then, results have been excellent. During 1984, the first full year of operation, revenue totaled $280 million. Direct operating costs totaled $122 million. The balance was used to retire the bonds sold to finance construction.

The cost of construction was $770 million. The cost of acquiring 100 train sets was $500 million. Government-backed bonds were issued by the French National Railroad to cover these costs. Because of better than expected results to date, officials anticipate paying off the bonds in 9 years.

Passenger acceptance has been high. The first class fare from Paris to Lyon is $33; second class, $22. Air fare for the same trip is $70. Because of this, Air Inter, France's internal air carrier, lost 63 percent of its traffic on this route when the TGV opened.

Officials believe the TGV has lured not only air and highway travelers to it, but has created a new class. They find that many people are traveling to Lyon for an evening to enjoy one of that city's fine restaurants.

Each country visited expressed a high degree of concern over their potential role in the U.S.-sponsored SDI program. For this reason, a special section has been added to this report.

STRATEGIC DEFENSE INITIATIVE (SDI)

Although there is some ambivalence regarding NATO participation in the US Strategic Defense Initiative (SDI) program among government officials based on strategic implications, the aerospace industry, particularly in West Germany, expressed a keen interest in participating in a meaningful way. There is a strong concensus that Western European industry be assigned much more than just individual, piecemeal research tasks, so that they can maximize technology transfer benefits to the civilian sector through their involvement in the SDI R&D phase. As the media has indicated, the French are not interested in participating directly in the US SDI, but are continuing their efforts to pursue a separate Western European program with other nations.

Although the SDI is a DOD/DOE R&D program presently authorized by the Armed Services Committees, the Europeans were most anxious to discuss the program in terms of how the Members of the Science and Technology Committee delegation see the initiative emerging in the US and, particularly, to explore avenues for cooperation and involvement in the R&D. The Committee delegation was primarily interested in the European perception of the SDI from the perspective of the significant potential for technology transfer to the civilian sector in the NATO countries, which has been a topic of great interest to the Committee since the initial days of NASA's technology utilization efforts. The European views on the merits of the SDI thrust range from a keen interest in both planning and carrying out R&D on the part of the industrial representatives, such as Messerschmitt-Bolkow-Blohm (MBB) officials, to the arms control concerns of certain government officials attesting to the ambivalency of the NATO community toward the program. The MBB officials cited specific areas which they believe that FRG industry can contribute in a unique fashion and these areas of computers, optics and materials were affirmed in discussions with the US Embassy Science Counselor in Bonn. Minister Riesenhuber wanted to know more about the SDI and indicated FRG concern as to what it means to NATO. He implied that the German position might be that they would prefer to carry out unclassified research so that the possibility of technology transfer to the civilian sector would be enhanced. The S&T delegation indicated that it is too early in the program planning to identify what precise areas to which FRG industry could best contribute. The FRG officials seemed to believe that there was some inconsistency between Secretary Weinberger's message to NATO and the more flexible indications from the SDIO as to the potential role of NATO allies in

various system architectures, e.g., that the Europeans might play a major role in defense against short-range missiles rather than strictly concentrating on ICBM defense, since that is their more proximate strategic problem. This view is similar to the view expressed by MBB personnel in that they worried about such a concentration on ICBM defenses on the part of the US because it could leave them at risk to the Russian IRBM's and have potentially serious strategic nuclear implications for all of NATO. Minister Riesenhuber emphasized his concern that the FRG might make best civilian use of research results and technology developed. There was some discussion of General Abrahamson's delineation of his needs and the SDIO's attention to judging the potential for civilian spin-offs, at home or abroad. The delegation pointed out that the SDIO has indicated its intention to "fence off" a certain percentage of funds for innovative technology, concentrating on unclassified university research and that this category might be broadened to include unclassified industry research. The Minister confirmed the FRG position that industry can go ahead and negotiate roles directly in the program as long as the nature of their contract with the DOD is not in violation of FRG government policy. He also noted that they have a good idea of the technologies involved in the SDI and understand that the program touches many fields, from advanced materials science to extremely complex hardware and software requirements in computer systems.

The articles in Appendix H comprise a fairly accurate reflection of the general view that the delegation sensed in West Germany, i.e., that despite arms control concerns about the ultimate strategic balance in Western Europe, neither government nor industry believes that the FRG "can afford not to play" in the SDI game.

The meeting with US Embassy officials and related discussions with Swedish scientists confirmed that the Swedish government does not wish to be involved in the SDI, although there are certain Swedish industrial firms that are interested in the R&D. It is not clear as to whether the present Swedish government would permit significant involvement in the SDI by Swedish industry.

There was a brief discussion of the French view of the SDI with US officials at the Embassy in Paris.

The articles in Appendix H provide a very good assessment of U.S./NATO interaction on SDI, the French interest in a separate European program on strategic defense technologies, and the stalemate among NATO partners which has resulted from the French campaign to obtain British and West German cooperation in the Eureka program.

APPENDIX A

2
ADVANCED REACTOR DESIGN CHARACTERISTICS

The USNRC draft policy for advanced reactors encourages applicants to design reactors with some or all of a set of seven characteristics. This chapter reviews PIUS plant designs in the light of these proposed characteristics.

No 1 Proposed Characteristic. Simplification of safety system design and operation

Proposal text

Applicants are encouraged to design and construct advanced reactors, which provide designs that do not require many supplemental safety features to meet NRC safety standards and/or designs that provide long lead times during off-normal operation prior to any required mitigative action.

PIUS and proposal 1

With respect to safety features needed to meet NRC safety standards, PIUS plants are characterized by:

- The protection of the public against the effects of core degradation only requires the passive pool and natural circulation features inside the concrete vessel and the vessel pressure relief valves
- The protection of the public against the release of radioactive matter, accumulated in the reactor water during normal plant operation, only requires a few isolation valve systems, which are protected by concrete vessel features.
- Other protection systems exist in PIUS plants and are largely identical with safety systems in conventional LWR plants. In PIUS plants these systems serve the purposes of protecting plant capital investment and plant availability and of preventing unnecessary activation of the ultimate pool-related safety functions.

The provision of long lead times before mitigative action is needed during abnormal plant conditions is given by the following features with respect to the protection of the public:

- The reactor pool gives a seven day supply of unattended core residual power removal without any power supply.
- The reactor pool is protected against rupture of the concrete vessel by redundant load-bearing members.
- The reactor pool is protected against leakage by redundant leakage protection membranes.
- Additionally regular cooling systems exist as in other LWR plants. There are not safety grade systems.

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- Prevention of mechanical challenges by other plant systems to the safety systems through the sheer massiveness of the concrete vessel.

- Prevention of corresponding electrical challenges by making the safety systems independent of electrical power.

This means that the balance of plant, which in this case consists of the whole plant outside the immediate protection of the concrete vessel will be non-safety-grade. This is difficult to accept for most nuclear engineers for systems such as diesels and batteries but must be accepted if the PIUS way of compliance with proposal 3 shall be upheld.

No 4 Proposal Characteristic. Plant standardization

Proposal text

Applicants are encouraged to design and construct advanced reactors, which in turn encourage the development of more complete standardized plant designs and minimize the potential for field construction fabrication errors via increased shop fabrication without introducing offsetting difficulties in factory-to-field transport and installation and in maintenance in the operating plant.

PIUS and proposal 4

Standardization of PIUS plants is encouraged by the introduction of the module plant model where the modules are complete steam generating systems, which may share one concrete vessel. The current intentions are that the standard should be 670 MW(th), which would give about 200 MW(e). This allows for three modules in a 13 m diameter concrete vessel cavity.

Standardization of this kind will also simplify greatly plant startup and operator training etc.

Those parts of the RCPB which are important to the core integrity are altogether field constructed. The steam generating systems can, on the other hand, be altogether fabricated in shop. They need not be installed in the plant until civil engineering construction has been completed.

Whether maintenance will be more difficult in PIUS plants than in conventional PWR plants or less so, as we believe, will remain a matter of contention until tested out.

No 5 Proposed Characteristic. Maintaining safe shutdown conditions

Proposal text

Applicants are encouraged to design and construct advanced reactors where the number of components whose functioning is essential to maintenance of safe shutdown conditions is minimized.

PIUS and proposal 5

PIUS plants are kept shut down by the inherent ingress of borated water in the primary system if the scram valve ingress were to fail. No scram rods are credited or needed.

No 6 Proposed Characteristic. Plant complexity

Proposal text

Applicants are encouraged to design and construct advanced reactors, which are less complex, thereby permitting reliance on simpler safety analyses and facilitating operator comprehension and reliable system function for off-normal conditions.

PIUS and proposal 6

With respect to proposal 6, PIUS plants are characterized by the following:

- The safety systems are limited to the concrete vessel and have few active components, the main ones being the concrete vessel relief valves.
- The monitoring of the nuclear part of the plant thus becomes relatively simple, but an SPD system will still be supplied for accidents which leave the electric systems and the control room intact.

No 7 Proposed Characteristic. Operation and maintenance

Proposal text

Applicants are encouraged to design and construct advanced reactors, which provide designs that improve reliability and maintenance, and that reduce potential radiation exposures to plant workers.

PIUS and proposal 7

With respect to proposal 7, PIUS plants can be characterized in the following way:

- Safety system reliability should be considerably improved as compared with conventional LWR plants, as these systems have very few active components.
- Plant overall reliability can, on the other hand, not be expected to improve, as PIUS plants will utilize conventional turbine plants.
- Steam generator tube plugging should be considerably improved in comparison with conventional PWR plants, as the steam generator tube sheets are easy to reach and have low radiation dose rates.
- Whether maintenance altogether will be more difficult in PIUS plants than in conventional PWR plants or less so, as we believe, will remain a matter of contention until tested out.
- Radiation exposures to plant personnel should be lower than in conventional PWR plants for three reasons:
  - The steam generators are shielded by reactor pool water when serviced.
  - There are few systems which get contaminated and which need safety-related inspection.
  - There are few components which become activated by neutrons and which need safety-related inspection.

Denna handling får ej utan skriftligt medgivande kopieras. Den får ej heller utan sådant medgivande utlämnas till annan eller på annat sätt göras tillgänglig för annans obehöriga användning. Detta gäller såväl hela handlingen som delar av den. Förbudet gäller varje form av kopiering och annan mångfaldigande åtgärd, oavsett om den sker helt eller delvis och oavsett vilken teknik som används. Förbudet gäller också användning för offentliggörande. Upphovsrätten tillkommer ASEA-ATOM

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4
NUCLEAR ISLAND DESCRIPTION

4.1
Unique PIUS features

The PIUS nuclear island is characterized by three unique features:

- The concrete vessel (4.2) which houses and protects the primary reactor systems and all those systems which perform the ultimate safety functions.
- The reactor pool (4.3), where enough water for at least one week of residual heat removal from the core and spent fuel storage by boiling is always available at reactor pressure.
- The two-loop core cooling system (4.5), which performs the ultimate safety functions of shutting down and cooling the reactor.

4.2
The concrete vessel

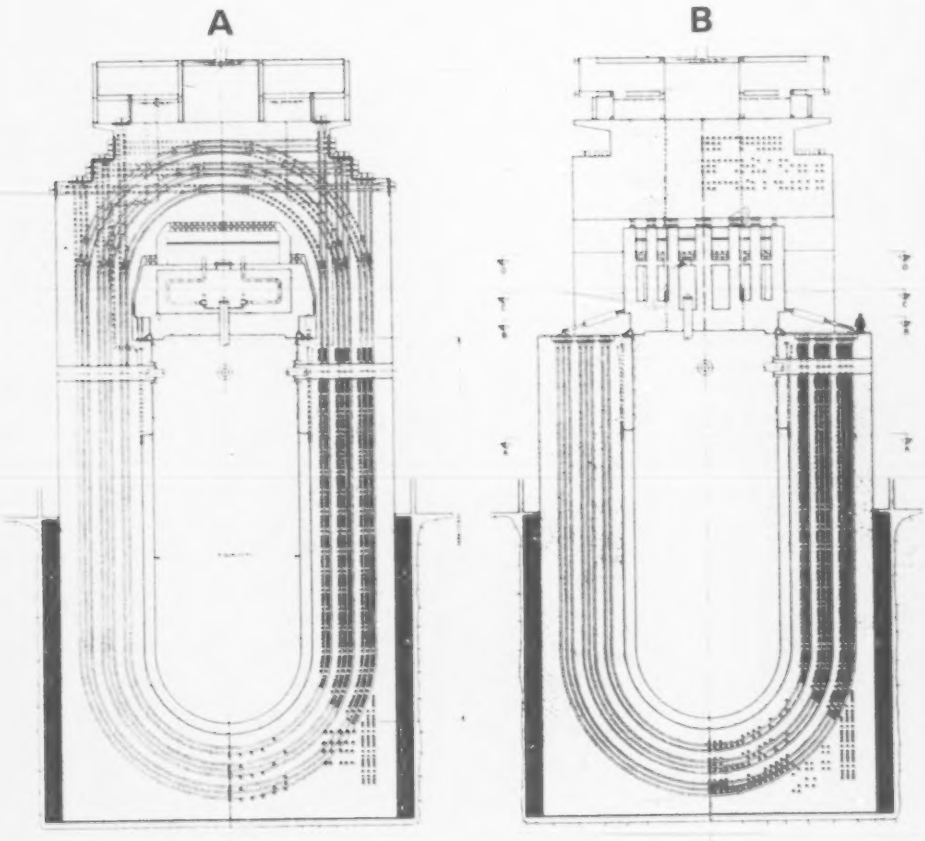
The PIUS concrete vessel is a prestressed monolith with a central cavity and a drawer-like closure slab, as shown in Figures 4.2 A and 4.2 B. The vessel has a wall thickness of 25 to 30 feet (8 to 10 m) and a weight of around 100.000 tons. The vessel is designed for an operating pressure of 1300 psi (9.0 MPa) and normally operates at temperatures of 100 to 150°F (40 to 60°C).

The PIUS concrete vessel is more thickwalled and designed for higher pressures than are those prestressed concrete vessels that have so far been employed in nuclear plants. It is a considerably more simple design than are these existing concrete reactor vessels, however, and it is also less complicated than the ASEA-ATOM prestressed concrete containment vessels. From these latter vessels the PIUS concrete vessel has borrowed the imbedded carbon steel membrane, a feature used in almost all Scandinavian containments. The PIUS vessel also has a stainless steel liner, and the two steel membranes act as redundant barriers against vessel leakage in the lower parts of the vessel, where the walls have no penetrations for pipes or cables etc.

Tests of high pressure concrete vessels for LWR plants were performed at the Studsvik laboratories in Sweden several years ago.

The concrete vessel cavity is made available over its full diameter, when the concrete closure slab has been removed. Refuelling and maintenance (7.2) can therefore be performed as easily in PIUS plants as in conventional nuclear plants. During plant operation the closure slab is subjected to compression and not to tension, thanks to the arch design of the vessel monolith and the wedging of the slab against the arch. This design feature has been adapted to PIUS from the ASEA Quintus presses, which are used extensively in industry in the US and elsewhere.

Prestressed concrete vessel for PIUS plants of 500 to 600 MW(e)



The construction of the PIUS concrete pressure vessel lies well within the capabilities of current technology for prestressed concrete structures. This fact has been established in studies made by two large independent Swedish companies, both of which are experts and pioneers in this area of technology (7.1).

Concrete vessels must operate at low temperature with current concrete technology and have therefore not been used before in LWR plants. In PIUS the vessel cavity is filled with a pool of cold water, called the reactor pool (4.3), and is normally not subjected to higher temperatures than 150 °F (60°C). The absence of a hot thickwalled steel pressure vessel carries the advantage that sudden depressurization and cooling down of the primary system will not cause destructive thermal stresses in PIUS plants as it may do in conventional LWR plants.

The 25 to 30 feet (8 to 10 m) thick walls of the PIUS concrete vessel are the protective element in the plant against physical damage by explosions and fires etc. They are also the platform onto which the systems inside the vessel are anchored for protection against earthquake forces, the effects of which are further discussed in chapter 8.5.

Two accidents could hurt the concrete vessel thermally. One is an all engulfing fire outside the vessel, which could conceivably destroy the prestressing cable anchors. The other is a continued several day blow-down by the reactor pool of the core residual heat, as described in chapter 4.3, which could happen if the plant personnel have left the plant permanently (8.4) or if the BOP around the concrete vessel has been destroyed (8.5). In these cases the concrete vessel may not be possible to re-use, but the rebars and the imbedded membrane will make it meet its safety tasks throughout the course of the accident.

4.3
The reactor pool

The reactor pool is a body of water, which fills up the cavity of the concrete vessel. For a 500 MW(e) plant, the volume of this pool is about one million gallons (4000 m^3). The water is borated and is kept cool by a conventional heat removal system with a closed cooling system and a service water system. The normal operating temperature varies between 100 and 150 °F (40 and 60°C).

The reactor pool has the following tasks:

- To supply the reactor primary system (4.5) with water for the plant ultimate safety functions.
- To house and cool all the systems inside the concrete vessel as listed below
- To insulate the concrete vessel thermally from the primary system

The systems immersed in the reactor pool are:

- The reactor primary system (4.5)
- The concrete vessel pressurizer
- The storage for spent fuel
- Sensors and cables for instrument systems
- Pool auxiliary systems

The pool and the systems immersed in it are shown in Figures 4.5.E and F.

The reactor pool has an open surface connection with the pressurizer steam volume and via this pressurizer to the plant environment through relief valves.

The reactor pool of the PIUS plant replaces most of the core protection systems in conventional LWR plants. The pool supplies the primary system with

- Borated water via scram valves for normal reactor scram.

- Borated water for the reactor ultimate safety reactor shut down function (4.5)

- Water for residual heat removal by boiling, also an ultimate safety function.

Reactor scram and reactor shutdown by the activation of the ultimate shutdown system both eject hot primary system water into the reactor pool. The pool cooling system then protects the concrete vessel from excessive temperatures. In extreme cases, where all regular cooling systems are destroyed or immobilized, the reactor pool heats up until it starts boiling and the reactor residual power is blown off to the plant environment via the relief valves or through pipes which may have ruptured during the accident.

The spent fuel is stored in the reactor pool around the core. It is thus protected against loss of coolant and physical abuse as thoroughly as is the core. The spent fuel storage will house from 15 to 30 years of spent fuel, depending on how elaborate the fuel handling systems are made.

4.4
The reactor core and the reactivity control systems

The PIUS reactor core is a conservatively designed LWR core, in all respects well within the technology applied in conventional nuclear plants. The power density and the fuel rod diameter are closely equal to the same parameters in modern BWR plants.

The operating principles for PIUS are those of a modern PWR plant, however. The outlet of the hot channel is kept at saturated conditions. As the driving pressure for the core coolant flow is quite low (4.5), the core height will only be a fraction of that in a PWR, or about 80 inches (2 m).

The PIUS reactor power is controlled by burnable absorber and by borated water from a pump injection system.

Control rods with drives such as those employed in conventional LWR plants are not compatible with the safety requirements imposed on PIUS plants. There are no physical obstacles to the introduction of scram rods in PIUS reactors, however, but it is the firm opinion of ASEA-ATOM that such a system is not needed. The reactor can be shut down in four ways without scram rods:

- By the reactivity control system pumping borated water from outside the concrete vessel into the primary system.
- By opening of the scram valves, which makes pool water enter the primary system thanks to pressure differences induced by the recirculation pumps.
- By tripping of the recirculation pumps, which makes reactor pool water enter the primary system by natural circulation.
- By tripping of the ultimate safety function of reactor pool water entering the primary system due to core moderator voiding or to recirculation pump trip as above.

4.5
The reactor primary system

The components of the reactor primary system are shown in figures 4.5.E and F and, beside the core (4.4), are the following:

- The reactor riser
- The pool loop inactivation system with the two density locks
- The recirculation loops and pumps
- The steam generators

Figures 4.5.A through 4.5.D explain how the primary system operates.

Figure A shows a vertical pipe, 70 to 80 feet (20 to 25 m) high, which is immersed in the reactor pool. There is a heat source, such as a reactor core, at the bottom of the pipe, and water circulates in a natural mode, as shown by the arrows.

The vertical pipe is what is called the reactor riser in PIUS. The flow in this riser will attain a rate, where the density difference between the riser water and the pool water balances out the flow-induced losses in the heat source and the riser.

In Figure B, a pump system or recirculation system has been attached to the upper and lower ends of the riser. If the same flow rate of water is pumped through the pump system as passes up the riser by natural circulation, no water needs to pass out into the pool. If the pump is stopped, natural circulation via the pool will immediately begin.

In Figure C a heat exchanger has been introduced in the recirculation system, and the primary system operates at higher temperature than in Figures A and B. The constrictions of the riser upper and lower ends have been transformed into so-called density locks with pipe bundles and/or honeycombs, which provide quiescent conditions in the locks. In order to achieve stability, the upper lock has been turned upside down, putting the hot water on top of the cold water. During plant operation, the primary system operates at low boron concentration and high temperature, and the pool at high boron concentration and low temperature. The heat exchanger or steam generator removes the heat generated in the reactor. If the recirculation pump is stopped, natural circulation via the pool will immediately begin as in the case of Figure B.

The feature of density locks has been and is being subjected to very extensive laboratory verification tests. The dynamic behavior of the locks is discussed in chapter 6.5.

In Figure D, a pressurizer has been added to the system.

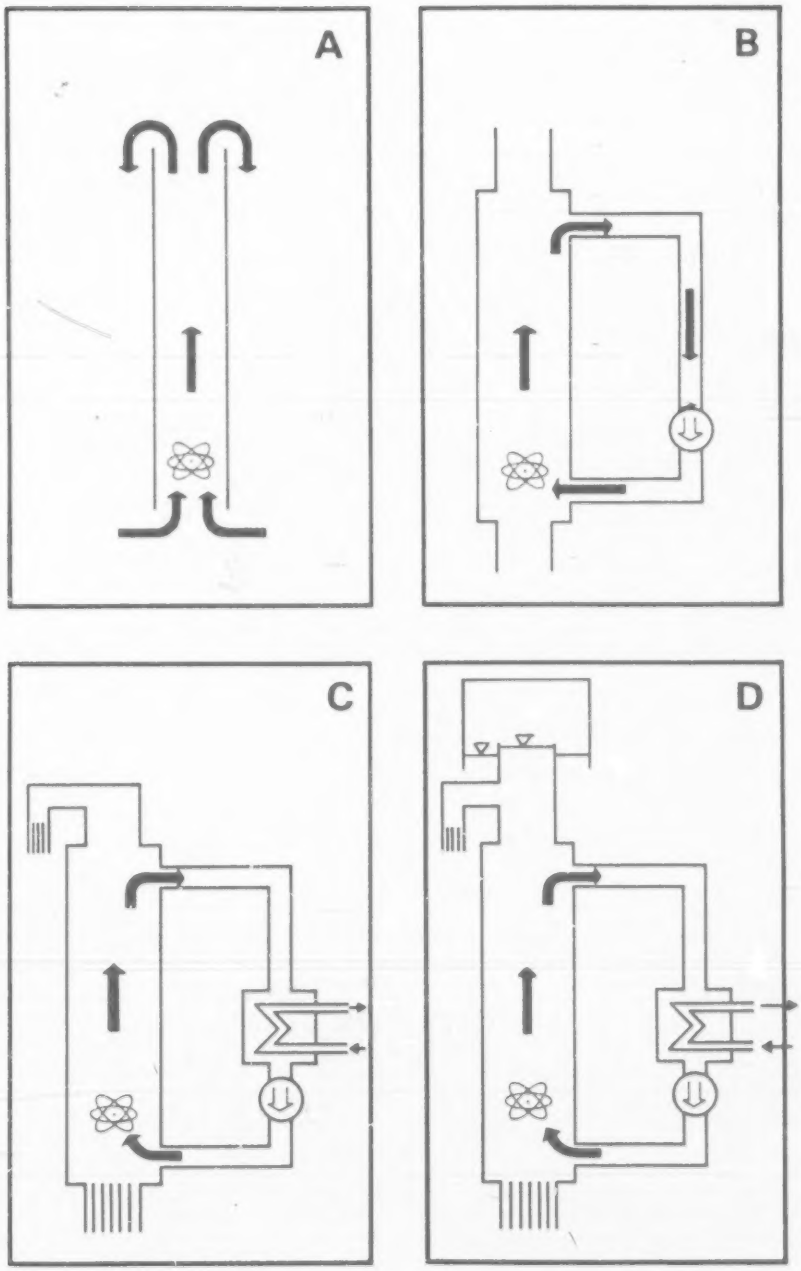
The PIUS steam generators will be once-through units with the primary water on the shell side in order to give good load-following characteristics to the plant.

The recirculation pumps are of very closely the same design as the wet motor pumps that ASEA-ATOM has employed in all of its BWR plants. The PIUS pumps are in fact considerably less complicated than the pumps of the most recent six AA BWR plants. The fact that the PIUS pumps operate with water outside the motor casing as well as inside it is not considered a problem.

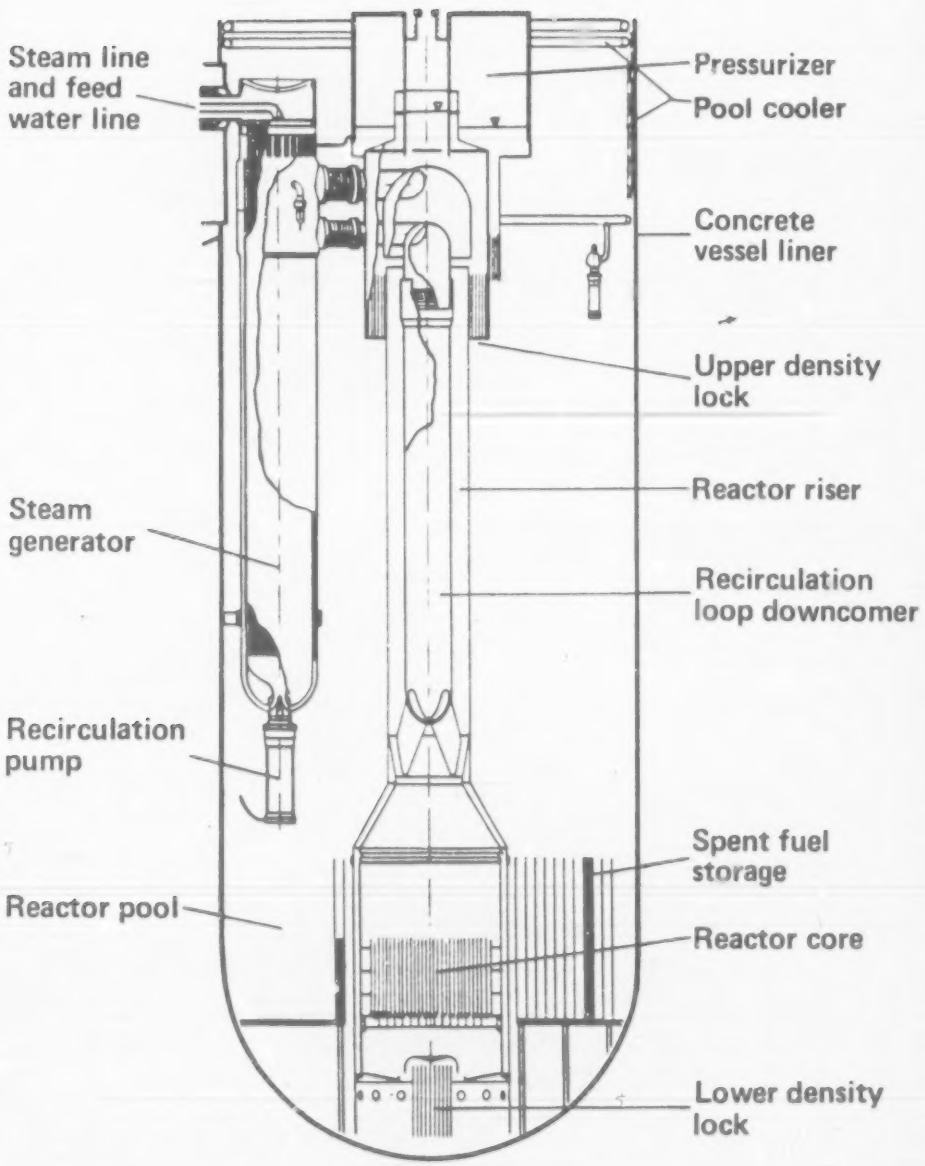
The modularized type PIUS plants have one recirculation pump and one steam generator for each module. Non-modularized plants may have four and perhaps more loops, each with its pump and steam generator and all serving the same core.

The primary system is insulated thermally towards the reactor pool by a metallic insulation system. This system was developed in France for gas-cooled reactors, but it was tested for immersion in water during the Studsvik concrete vessel development tests.

The operating principles of the PIUS primary system



The primary system of a non–modularized 500 MW(e) PIUS plant



APPENDIX B

MAX PLANCK INSTITUTE

1.2 History of the Institute

The application to the then Federal Ministry of Atomic Energy to support a fusion research centre at Garching envisaged the institute as a body with separate legal status, both because the size required would exceed the scope of other Max Planck establishments and because an independent status was necessary for cooperation with EURATOM. For practical reasons the search for a specific form of organization then culminated in the formation of a joint-stock company owned by the Max Planck Society.

The then responsible Federal Minister, *Siegfried Balke*, recalls: "First it was necessary to dispel doubts about the scientific usefulness of intensifying the study of plasma physics. As the financial resources available to the Government at the time were very modest and sound justification was required for new areas of research, these objections had to be rigorously scrutinized. It was *Werner Heisenberg's* authority which then succeeded in overcoming these reservations."

After discussion of the project in the "Nuclear Physics" study group of the German Atomic Energy Commission and in the "Plasma Physics" committee of experts, Federal Minister *Balke* granted the Max Planck Society in 1959 Federal funds totalling almost ten million marks to construct and equip a fusion research establishment at Garching in 1959 and 1960.

In pursuance of the resolution passed by the Senate of the Max Planck Society on 16th March 1960 to found the Insti-

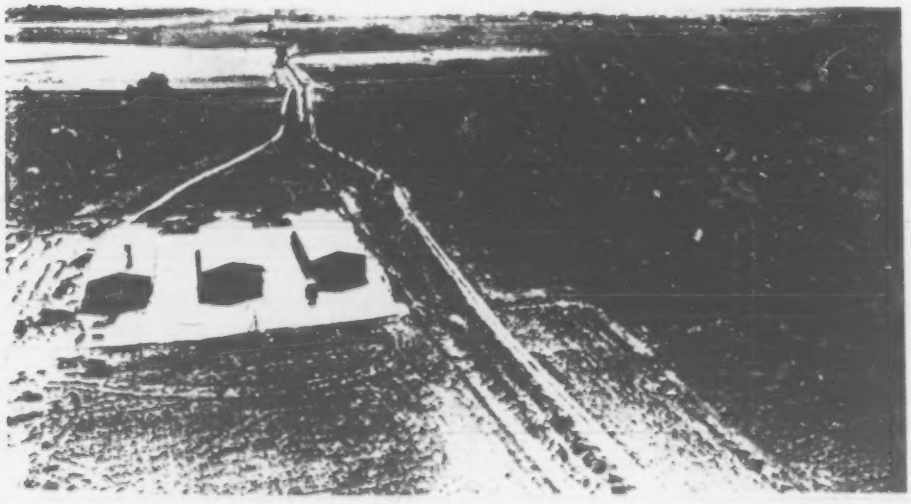


Fig. 1
It all began with three huts. Starting in 1960, Institut für Plasmaphysik was set up north-east of Garching. The three huts accommodated the first laboratories and offices.

tute, the deed of association between the Max Planck Society and *Werner Heisenberg* was ratified on 28th June 1960.

The nucleus of the Institute was formed by a group for theoretical plasma physics headed by *Arnulf Schlüter*, an experimental division headed by *Gerhart von Gierke* (both from Max-Planck-Institut für Physik und Astrophysik) and a group for technical physics from the Technical University of Munich, headed by *Ewald Fünfer*, which had already done preliminary work in plasma physics. In addition, an experimental group from the University of Kiel, headed by Rudolf Wienecke, was incorporated into the institute. To cope with the large experiments planned, an engineering division headed by *Karl-Heinz Schmitter* was set up to perform independent engineering work and provide the necessary technical services. An administration headed by *Adolf Ilse* was also set up to handle commercial and administrative matters.

This historically evolved structure allowed the range of research topics to be extended by the founding of further scientific divisions headed by *Dieter Pfirsch*, *Siegbert Witkowski*, *Günter Grieger* and *Friedrich Hertweck*. As of 1973 scientific projects with given, clearly defined objectives were set up and grouped in divisions handling allied topics.

The scientific divisions were supported by data acquisition and processing facilities, administration and general services, and central technical workshops. This basic pattern has since proved its worth.

The first Board of Scientific Directors was composed of *Werner Heisenberg* and *Ludwig Biermann* together with the other Scientific Fellows. From January 1965 this body, which draws up and supervises the scientific and technical programme of the Institute, was headed by *Arnulf Schlüter*, and from 1973 to 1981 by *Rudolf Wienecke*. Since 1st April 1981 it has been headed by *Klaus Pinkau*.

The Chairman of the first Supervisory Board was *Siegfried Balke*, with *Adolf Butenandt* as Deputy Chairman. *Ernst Telschow* took office as Managing Director in June 1959 and retained this position till the end of 1967, when he was succeeded by *Arnulf Schlüter*. On 1st October 1961 *Günter Lehr* was appointed joint Managing Director. He was succeeded on 1st April 1968 by *Ernst-Joachim Meusel*.

On 1st January 1971 IPP was integrated in the Max Planck Society as Max-Planck-Institut für Plasmaphysik. The previous instruments of a Supervisory Board and shareholders' meeting were now replaced by a Board of Trustees. In all scientific matters IPP also consults an Advisory Board composed of reputed scientists from Germany and abroad without IPP affiliation.

Until 31st March 1981, IPP, in keeping with its constitution, was run by a Directorate with *Rudolf Wienecke* as Principal Scientific Director, *Ernst-Joachim Meusel* as Managing Director, *Gerhart von Gierke* and *Arnulf Schlüter*. On 1st April 1981 *Klaus Pinkau* became the new Chairman, with *Günter Grieger* and *Michael Kaufmann* succeeding *von Gierke* and *Schlüter*.

The constitution defines the objective of IPP as the pursuit of research in plasma physics and allied fields and the development of the methods and tools needed for such research. Three lines of attack were initially pursued.

The first was to produce by fast magnetic compression a plasma with the

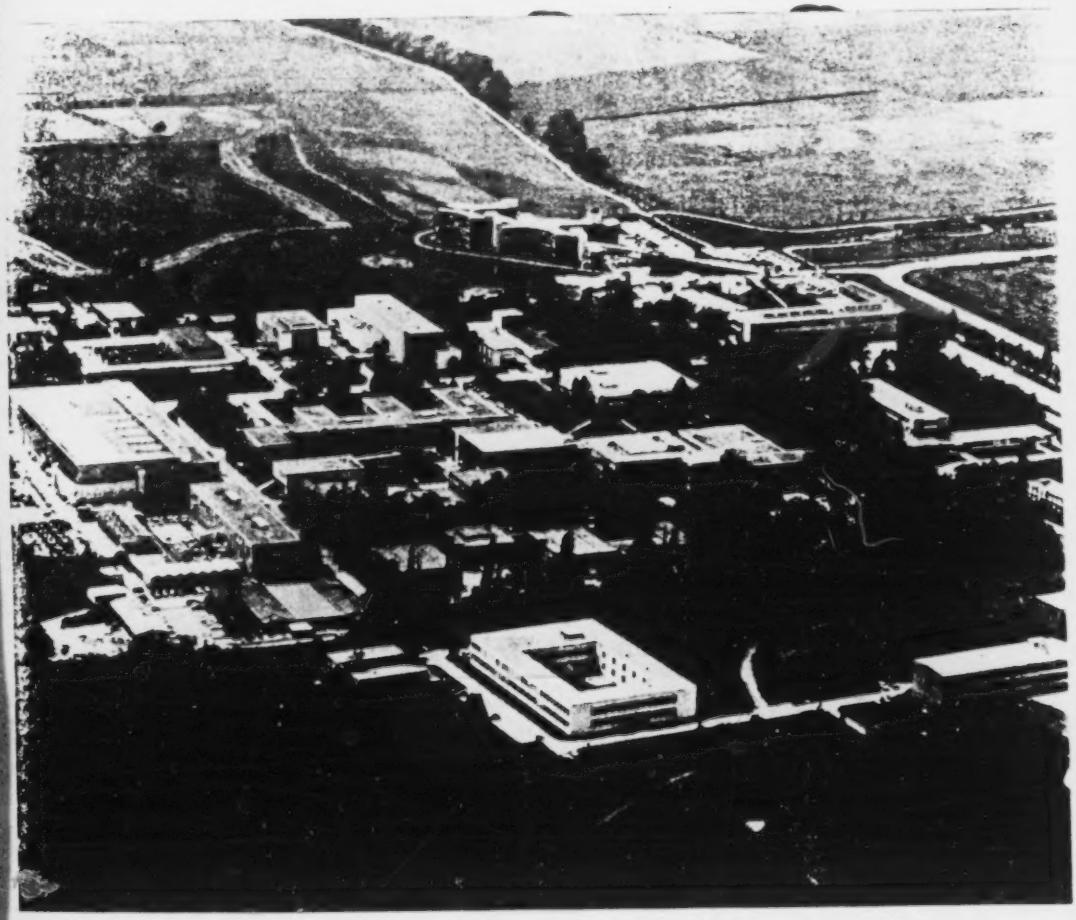


Fig. 2
IPP occupies a 60-acre site by the River Isar on the northern outskirts of Munich.

highest possible temperature and not too low a density. This comes closest to achieving the desired state of a hot fusion plasma but involves difficulties of analysis since the dynamic behaviour of the plasma is highly complex and the confinement times are severely limited in experimental devices by instabilities and particle losses.

The second aim was to produce an almost completely ionized plasma in almost stationary thermal equilibrium. The properties of such a plasma are easier to measure, thus pointing the way to more advanced experiments. Since the seventies research throughout the world has concentrated on projects which were regarded as being relevant to the construction of a fusion reactor. This has brought problems of engineering to the fore.

The third objective was to investigate model plasmas, the aim being not to approximate the physical conditions of a fusion plasma but to analyze in detail the behaviour of the charged particles confined by the magnetic field.

This general development was not without influence on the scientific programme of IPP. It had already been

decided in 1974 to confine attention to investigations of magnetic confinement and discontinue work on laser fusion at the end of 1975 – failing additional support to meet personnel requirements. Moreover, the programme of IPP had to be further pared since the increasing size of experiments called for more personnel. Activities had to be concentrated on individual, particularly promising research topics in order to solve the problems of fusion research by international division of labour.

On 1st January 1975 work in the field of laser fusion was transferred to the new "Project Group for Laser Research", which in 1981 became Max-Planck-Institut für Quantenoptik.

The programme of IPP was therefore concentrated on the large projects, ASDEX, Pulsator, Wendelstein VII, High Beta Stellarator and Belt Pinch, for investigating the magnetic confinement of hot plasmas by the tokamak and stellarator principles. This work was accompanied by investigation of fundamental processes in plasma-wall interaction and surface physics as well as in collective acceleration with relativistic electron rings.

The decision in October 1977 to build the joint European fusion experiment, JET (Joint European Torus), at Culham (U.K.) and the preparations for the European fusion programme for the period 1979 to 1983 called for a reassessment of the scientific programme of IPP. The Pulsator (Garching) and Alcator (MIT, Cambridge, U.S.A.) experiments had succeeded in reaching the high-density regime and appreciably increasing the energy confinement time of the plasma. In January 1978 these results formed the basis for a new study group at IPP investigating thermonuclear heating in a high-field tokamak. Thermonuclear heating with the alpha particles released in deuterium-tritium fusion constitutes one of the most important experimental problems on the road to an energy-yielding fusion reactor.

In March 1979 the Board of Scientific Directors decided to allocate a major part of the Institute's capacity to such a high-field tokamak ignition experiment after clarifying in a concept phase the most important physical and technical problems involved in its design. In order to meet personnel and equipment requirements, some projects (Belt Pinch, INTEREX, PUSTAREX, Pulsator) were terminated in 1979, and the Pellet Plasma Source experiment was discontinued in 1980, while the programmes in other areas were restricted.

As the tokamak configuration involves specific disadvantages for a fusion reactor, it was also decided – albeit with much less outlay – to investigate toroidal confinement with external magnetic fields (instead of with induced currents) as a possible alternative. For this purpose a study group was formed to extend the work on Wendelstein by planning experimental investigations on net-current-free plasma confinement with externally applied magnetic fields and by optimizing the experimental parameters.

In July 1979 a High-frequency Heating project was started with the object of heating plasma with high-frequency electromagnetic waves in the ASDEX, Wendelstein VII-A and ZEPHYR devices. In addition, preparations are being made in collaboration with CEN, Grenoble, to apply lower hybrid frequency heating in ASDEX.

In the first half of 1980 the ASDEX divertor experiment succeeded in main-

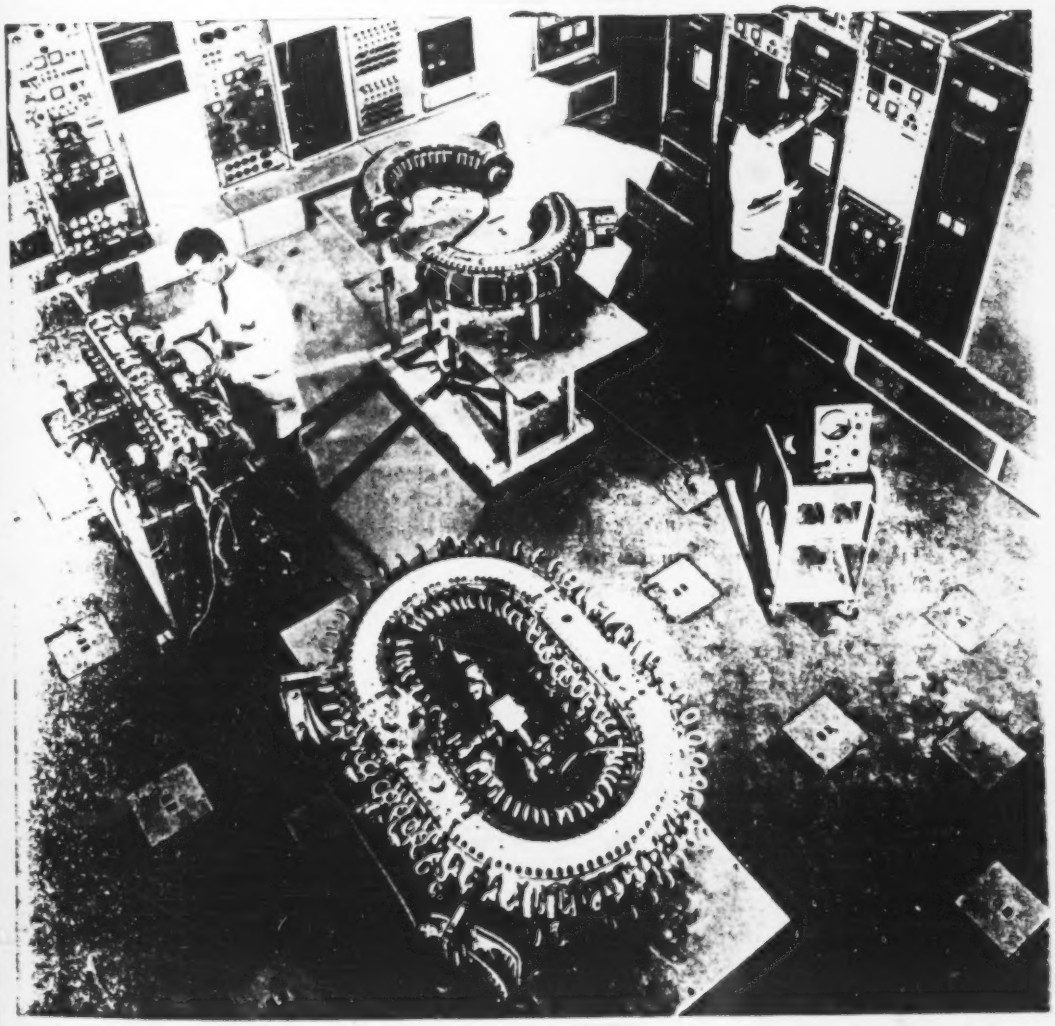


Fig. 3

Wendelstein Ia (middle foreground) and Wendelstein Ib (middle background) were the first stellarators at IPP. These were racetrack-shaped devices with straight sections intervening between the two torus halves. These intermediate sections were mainly intended to accommodate the various diagnostic facilities. Since, however, they prevent the formation of closed magnetic surfaces, this configuration was not used for later devices. On the left is a straight configuration, Wendelstein IV, which was used for testing the production of caesium plasmas such as were used in the experiments then being conducted. The photo was taken in 1963.

taining discharges in relatively clean plasmas for hitherto unattained times of up to three seconds without current disruption. The discharge time was even increased to 12 seconds by lowering the plasma density. During the same period neutral injection heating was applied in the Wendelstein VII-A stellarator experiment, yielding for the first time net-current-free plasma, i.e. demonstrating plasma confinement in an external magnetic field.

It became clear in the course of 1980 that the ZEPHYR ignition experiment

would involve considerable expense. The problems to be solved with ZEPHYR were therefore shelved till a later stage in the international fusion programme.

In view of the successes with ASDEX in conjunction with the now evident need for preparing a divertor for plasma control in the fusion reactor the ASDEX tokamak programme was reformulated to include a line for dealing with this complex of questions by the end of the eighties. This topic was defined in appropriate studies as of 1980.

The doubts as to whether a tokamak will ultimately constitute the confinement method of a fusion reactor still persist. The success achieved with the Wendelstein VII-A experiment has encouraged IPP to continue experiments with stellarators. The objective here is to investigate whether the stellarator principle is suitable for a fusion reactor.

All experiments and planning are carried out in close conjunction with theoretical studies. Large computers are becoming more and more indispensable as tools for theoretical work. After just two years in existence, IPP therefore acquired a computer of the type IBM 7090, one of the largest available at that time.

The subsequent rapid growth of computing requirements called for an even more powerful computer. At the beginning of 1969 an IBM 360/91 was installed, again the biggest and fastest model then available but, above all, the machine with the biggest quick-access storage (2 million bytes).

In 1972 computer operations were transferred from the Theory Division to

Fig. 4
Edward Teller in conversation with Arnulf Schlüter and Werner Heisenberg (from left) in 1972 at the Max-Planck-Institut für Plasmaphysik.

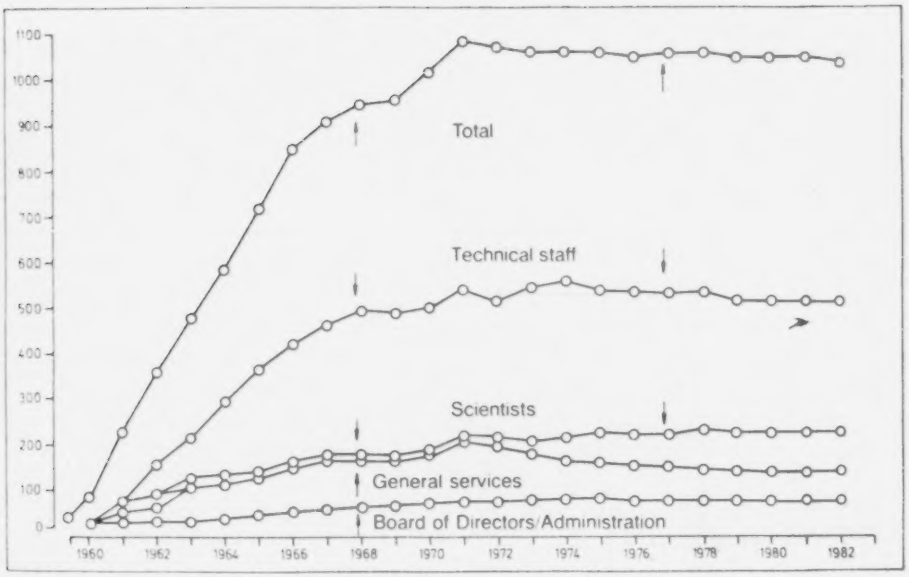


Fig. 5: Staff of Max-Planck-Institut für Plasmaphysik from 1960 to 1982.

the new Computer Science Division. As this division also served the Munich-based Max-Planck-Institut für Physik und Astrophysik, the Technical University of Munich and – via remote data links – the Max Planck Institutes of Solid State Research in Stuttgart, Chemistry in Mainz and Meteorology in Hamburg, the computer was so much in demand that it had to be supplemented at the end of 1976 by an AMDAHL 470 owned by the Max Planck Society. After a time this machine could not cope either. The computer centre was therefore additionally equipped in the summer of 1979 with the CRAY-1 computer (more than 6 million bytes).

IPP is party to numerous contracts. Since 1961 it has been associated with the European Atomic Energy Community (EURATOM) by an agreement integrating it into the European fusion research programme. Under the provisions of this agreement about 25 per cent of the Institute's budget is funded by the European Community. Close cooperation is maintained with the Institute of Plasma Research at the University of Stuttgart, the work of which is geared in all major areas to the scientific programme of IPP. At Grenoble the WEGA fusion experiment for investigating high-frequency plasma heating was conducted jointly with Commissariat à l'Energie Atomique (CEA), France, and Ecole Royale Militaire at Brussels till the end of 1981. Close cooperation is also maintained with the nuclear research centre at Fontenay-aux-Roses in France and the U.K. research laboratory at Culham in developing high-power ion sources, and with the Technical Uni-

versity of Munich in investigating plasma-wall interaction. As part of the German fusion reactor programme IPP collaborates with the KfK nuclear research centre at Karlsruhe, particularly in superconductivity technology, with the KFA nuclear research centre at Jülich, and with Hahn-Meitner-Institut für Kernforschung (HMI) at Berlin.

Since 1979 IPP has been involved with the other EURATOM associates in studies being coordinated by the International Atomic Energy Authority at Vienna to produce a large-scale reactor-like experimental device (INTOR). The aim of this experiment is to have a fusion plasma burning as of about the mid-nineties and test critical reactor components close to actual operating conditions. This work has a close bearing on that for the Next European Torus (NET).

There is close contact with the two Munich Universities, at which IPP staff present lectures, particularly in plasma physics.

As of 1981 research policy for the JET European fusion experiment has been organized by a separate project group. It is preparing the contribution of IPP to the experimental programme of JET and is developing a series of special diagnostic facilities.

Chronicle

1955 First theoretical investigations of *Ludwig Biermann* and *Arnulf Schlüter* on thermonuclear fusion at MPI für Physik, Göttingen.

1956 Formation of Plasma Physics Study Group (*Arnulf Schlüter*) at MPI für Physik, Göttingen.

1957 Development of general stability theory of plasmas and study of toroidal magnetic confinement, including a proposal for confinement with azimuthal current (tokamak configuration).
Start of first experiments at Göttingen *(Gerhart von Gierke)* and Munich *(Ewald Fünfer)*.

1958 Formulation of a solution for non-rotational-symmetric external toroidal plasma confinement with the M-and-S (*Meyer* and *Schmidt*) configuration. Appropriate experiments first in the Kronentorus and then in the Lupus M-and-S-like configuration (till 1966).
Transfer of MPI für Physik to Munich.

1960 Foundation of Institut für Plasmaphysik (IPP) GmbH by the Max Planck Society with *Werner Heisenberg* as companion and *Ernst Telschow* as Managing Director (till 1965). Board of Scientific Directors: *Ludwig Biermann, Ewald Fünfer, Gerhart von Gierke, Werner Heisenberg, Arnulf Schlüter, Karl-Heinz Schmitter.*
Operation of first stellarator experiment (Wendelstein Ia).

1961 Theory of particle diffusion in toroidal magnetic field configurations formulated by *Dieter Pfirsch* and *Arnulf Schlüter* (Pfirsch-Schlüter diffusion).
Transfer of IPP to Garching. Conclusion of agreement on association with EURATOM. Appointment of *Günter Lehr* as Managing Director (till 1968).

1962 Start of investigations on rare-gas magnetohydrodynamic generators for enhancing the efficiency of conversion from thermal to electric energy (till 1972).

1963 Appointment of *Rudolf Wienecke* as Scientific Fellow.

1964 Operation of Isar I theta pinch experiment (till 1970). Fusion-relevant temperatures (60 million degrees for a few microseconds) attained by fast magnetic compression in theta pinch experiments. Successful measurement of electron temperatures by laser light scattering.
Demonstration of magnetic confinement of model plasmas with the Wendelstein Ib stellarator. Investigation of axisymmetric configurations with ring-shaped multipole coils.

1965 Appointment of *Arnulf Schlüter* as Chairman of the Board of Scientific Directors and as Principal Scientific Director (till 1973).

1967 Start of experimental and theoretical work on interaction of intense radiation with matter and plasma (laser fusion).

1968 Appointment of *Ernst-Joachim Meusel* as Managing Director. Appointment of *Dieter Pfirsch* as Scientific Fellow.

1969 Observation of nearly classical particle confinement behaviour (apart from enhanced particle losses at a certain rotational transform – resonances) in the Wendelstein IIa stellarator.

1970 Improvement of efficiency of rare-gas magnetohydrodynamic generators by suppressing ionization instabilities.
Development work on construction of a short-time combustion MHD generator for 10 MW/10 s (till 1972).
Appointment of *Siegert Witkowski* as Scientific Fellow.

1971 Conversion of IPP from Institut für Plasmaphysik GmbH to Max-Planck-Institut für Plasmaphysik.
Appointment of *Günter Grieger* as Scientific Fellow.

1972 Appointment of *Friedrich Hertweck* as Scientific Fellow.

1973 Appointment of *Rudolf Wienecke* as Chairman of the Board of Scientific Directors and as Principal Scientific Director.
Completion of Belt Pinch II experiment for investigating non-circular plasma cross-sections (till 1979).

1973 Operation of Pulsator tokamak experiment (till 1979); investigation of plasma parameter range attainable with tokamaks; with helical auxiliary fields it becomes possible for the first time to influence and investigate disruptive instabilities.
Start of planning of the ASDEX tokamak experiment with axisymmetric divertor.
Demonstration of stabilizing effect of stellarator fields in the Wendelstein IIb experiment.

1974 Demonstration of collective ion acceleration with the SCHUKO (till 1977) and PUSTAREX (till 1979) electron ring accelerator model experiments.
Demonstration in the Isar T1 high-beta stellarator that the plasma is not destroyed by certain oscillation states (MHD stability).

1975 Surpassing of the previously assumed density limit for tokamaks in the Pulsator experiment, thus yielding high values of the product of the confinement time and pressure of the plasma.
Operation of WEGA (at Grenoble) and demonstration of plasma heating with high-frequency waves at the lower hybrid frequency (till 1981).

1976 Operation of the Wendelstein VII-A stellarator; suppression of current disruptions with helical fields.

Work on laser fusion transferred to new Project Group for Laser Research of the Max Planck Society (as of 1981 Max-Planck-Institut für Quantenoptik).
Retirement of *Ewald Fünfer* (Professor Emeritus).

1977 Investigation of drift instabilities in the INTEREX linear experiment (till 1979). Choice of Culham (U.K.) as site of the JET European fusion experiment.
Appointment of *Gerhart von Gierke* and *Arnulf Schlüter* as further members of the Directorate (till 1981).

1978 Appointment of *Michael Kaufmann* as Scientific Fellow

1980 Operation of ASDEX axisymmetric divertor experiment; production of clean plasmas at discharge times of up to 12 seconds and temperatures of 30 million degrees.
Successful change to net-current-free operation in Wendelstein VII-A by means of four neutral injectors. Application of pellet injection for particle refuelling in W VII-A.
Study for the ZEPHYR ignition experiment.

1981 Appointment of *Klaus Pinkau* as Chairman of the Board of Scientific Directors and as Principal Scientific Director; appointment of *Günter Grieger* and *Michael Kaufmann* as further members of the Directorate.
Successful application of neutral injection heating and pellet injection in ASDEX. Development of various diagnostic methods for JET and preparation of IPP contributions to the experimental programme of JET. Submission of new concepts for future research work at IPP: Advanced Stellarator and ASDEX Upgrade.

1982 Start of construction of high-frequency heating for ASDEX and W VII-A.

APPENDIX C

Background Information on ASDEX

ASDEX and ASDEX-UG Programs:

The ASDEX tokamak at IPP-Garching has been in operation since 1980. It is the only major tokamak with poloidal divertor in operation at the present time in the world fusion program. IPP-Garching is fabricating ASDEX-Upgrade as a follow-on to ASDEX which will be in operation in 1987. Both of these facilities will provide IPP-Garching the opportunity to investigate in detail the physics of toroidal confinement and impurity control in tokamaks with poloidal divertors.

The basic parameters of ASDEX and ASDEX-UG are listed below:

	ASDEX	ASDEX-UG
Major radius, R	1.54	1.82
Average minor radius, a	0.40	0.52
Toroidal field	2.80	3.20
Plasma current	0.50	1.50
Pulse length	10	3-10
Auxilary heating powqer	15	3-5

The ASDEX program has made significant contributions to the world fusion program. In particular, the "H-mode" of operation has been discovered experimentally in ASDEX which improves confinement in beam heated plasmas. This discovery has been subsequently verified in D-III and PDX tokamaks in the U.S.

An IEA Agreement is being established, with the U.S. (DOE) and European Atomic Energy Community as the contracting parties, on a cooperative program in ASDEX and ASDEX-UG. This cooperation will provide the U.S. fusion program with important data base on toroidal physics and plasma technologies of poloidal divertors .

Background Information on WENDELSTEIN VII-AS

Up to now experiments have been conducted in so-called classical stellarators, the latest and largest of them being W VII-A. The German program is now aiming at plasma confinement in Advanced Stellarator configurations which reduce secondary currents. The advanced stellarator promises an increase in beta and even provides a stable burning point at reactor temperatures. During 1985-1986 W VII-A will be upgraded to W VII-AS to study the basic principles of the Advanced Stellarator concept. This device will be equipped with 1.5 MW NBI, 1.0 MW (70 GHz) ECRH and 3 MW (30-100 MHz) ICRH, all three of them capable of at least 3-s pulses. This should allow achieving significant densities and temperatures.

A new property of the W VII-AS configuration is the optimized structure of the magnetic field, different from the previous configuration in W VII-A. This concept of optimized magnetic fields also differs from HELIOTRON E (Japan) and URAGAN 3 (USSR). In these two other devices equipped with helical windings, high shear is needed for MHD stability. In W VII-A, however, the plasma equilibrium is optimized at a moderate rotational transform and MHD stability is ensured by a magnetic well.

The aims of the W VII-AS experiment are:

- to investigate plasma behavior in an optimized magnetic field configuration that should improve plasma equilibrium and lower transport losses compared to other configurations.

- to investigate a plasma without ohmic heating currents which drive instabilities and cause anomalous losses;

- to make use of a modular set of poloidally closed coils instead of the conventional helix/TF coil system; and

- to examine higher power heating methods.

The single modular coil system selected for W VII-AS replaced the two systems, helix and TF-coils, used so far, and thus removes one of the major obstacles for building larger stellarator devices or even stellarator reactors.

In parallel, the definition of W VII-X is being undertaken. This follow-up device to W VII-AS aims at demonstrating the basic reactor physics properties of the Advanced Stellarator concept.

An IEA Agreement is being established, with the U.S. (DOE) and European Atomic Energy Community as the contracting parties, on a cooperative program on W VII-AS and Advanced Toroidal Facility (ATF) at ORNL. This cooperation will provide the U.S. fusion program with an important data base on stellarator physics and performance. It is possible Japan may join this agreement later including its device, HELIOTRON-E, in this cooperative program.

The basic parameters of W VII-A and W VII-AS are listed below:

	W VII-A	W VII-AS
Major radius, R	2.0	2.0
Average minor radius, a	10	20
Toroidal field KG	35	30

4. Experiments Planned

4.1 Successors to ASDEX and Wendelstein VII-A

4.1.1 ASDEX Extended Performance and ASDEX Upgrade

The long discharge times and very low degree of plasma impurity achieved in the ASDEX divertor experiment have confirmed that a poloidal divertor is suitable for impurity control. It has allowed a stable and clean plasma to be maintained for more than 10 seconds. The experiments in ASDEX have also demonstrated that very good feedback control of the density, current and mean radius and operation without limiter allow the dangerous current disruptions to be appreciably moderated, thus reducing to a tolerable extent the mechanical load on the vessel coils due to disruptions.

These results suggest that the influence of the divertor on the behaviour of impurities and of hydrogen recycling from the walls should be investigated at higher wall loads as well. Furthermore, the ASDEX device is suitable for studying various plasma heating methods in one and the same machine and comparing them for efficiency. As the plasma cross-section in ASDEX can be varied, it is also possible to investigate the beta limits for circular and non-circular plasma cross-sections by enhanced plasma heating.

In a divertor experiment, which extracts particles from the plasma for impurity control, great importance is of course also attached to refuelling, one of the leading methods being injection of accelerated hydrogen pellets.

As heating in ASDEX with the plasma current alone (ohmic heating) only yields temperatures of up to about 10 million degrees (because the efficiency of ohmic heating decreases with increasing temperature), it is intended to build an Extended Performance version of ASDEX using other heating methods. The first stage of neutral injection has been in operation since the beginning of 1981 and the temperature has already been raised to about 20 million degrees, this being about twice the value achieved with purely ohmic heating. When the second neutral injection stage was put into operation in 1982, the neutral injection heating power was increased to 2.5 megawatts for 0.2 seconds, raising the temperature beyond 40 million degrees. Recently, it was found that deleterious effects of the neutral beam injection on the energy confine-

ment time of the plasma did not disappear until the heating power reached its highest values.

Besides plasma heating by high-energy neutral injection, numerous experiments have also had good results with heating with high-frequency electromagnetic waves. High-frequency heating at the lower hybrid frequency with a heating power of about 2 megawatts for 1.5 seconds is scheduled in ASDEX for early 1983.

The ASDEX plasma will also be subjected to another promising method of high-frequency heating, viz. ion cyclotron resonance heating, which is intended to afford a heating power of 2.5 megawatts at a pulse length of 10 seconds in order to allow impurity and recycling control with the divertor at enhanced wall loads of longer duration as well. The extended neutral injection heating being planned for ASDEX is also aiming at longer heating pulse lengths of 10 seconds and powers of between about 2.5 and 5 megawatts.

Besides extending ASDEX to full heating, there are also plans for an ASDEX Upgrade to clarify other important problems of fusion research that cannot be solved with the experimental facilities at present available or under construction. These plans are not only based on the experimental success achieved in ASDEX with the poloidal divertor. The international studies conducted for INTOR and NET had shown that a divertor with a poloidal field system outside the main field coils was needed for impurity control of future large experimental facilities. These plans were also prompted by the results of the ZEPHYR studies, which demonstrated the existence of a plasma boundary layer with high emission of electromagnetic energy (photosphere). This radiation layer can lead to the production of a cold gas blanket, which is necessary for the reactor-relevant plasma-wall interaction.

The design work for the ASDEX Upgrade is geared to the following requirements: it has to be provided with a reactor-relevant poloidal divertor (the poloidal field coils of which thus have to be installed outside the toroidal field coils, unlike in ASDEX); it has to ensure a sufficiently large product of the particle density and minor plasma radius to satisfy the condition for the existence of a radiation layer; and it has to allow long magnetic field and plasma current pulses. This will provide reactor-relevant and almost stationary conditions under which to study the plasma-wall interaction and the impurity behaviour in the plasma as well as the formation of a cold gas blanket by the photosphere.

4.1.2 Successor to Wendelstein VII-A

A successor to the Wendelstein VII-A stellarator is being planned on the basis of both the experimental successes with the W VII-A and the results of theoretical work in three-dimensional magnetic field systems. The net-current-free operation demonstrated in the W VII-A stellarator brought great improvement in the plasma confinement properties. The helical magnetic field components also allowed suppression of the dangerous current disruptions in operation with ohmic heating. The extensive theoretical work on three-dimensional magnetic field configurations (which, incidentally, could not have been done without the large CRAY-1 computer) showed that there are vacuum magnetic field config-

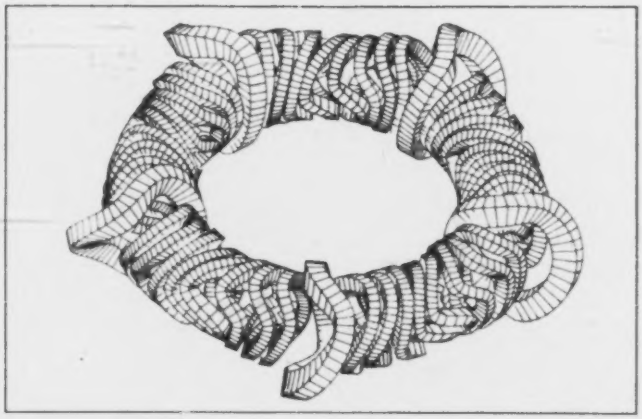


Fig. 36
A ring of specially shaped magnet coils to be used in the Wendelstein VII-AS stellarator.

urations which not only afford much better particle confinement than previous stellarator configurations, but also yield an enhanced value of the critical beta (which is important for the economy of the reactor).

This advanced stellarator configuration is intended to demonstrate the reactor potential of the stellarator principle, the improved particle confinement in net-current-free operation and enhancement of the critical beta values.

The W VII-AS (Advanced Stellarator) configuration is to be built with essential components of the present W VII-A structure. These investigations will be mainly concerned with quasi-stationary, net-current-free operation, the beta limits of a stellarator with reduced parallel current density and various plasma heating methods for producing high plasma temperature (over 10 million degrees). The stellarator field has to be generated with a modular coil system.

The (much larger) follow-up experiment planned – Wendelstein VII-X – is primarily aimed at investigating the long-term behaviour of the stellarator configuration, particularly the plasma-wall interaction and the impurity control in the stationary state, the plasma equilibrium and its stability at high beta values (of 5 to 10 per cent, the target for the reactor), the application of high-power heating methods and the properties of the modular coil system.

4.2 World-wide Cooperation on INTOR and NET

Under the auspices of the International Atomic Energy Agency (IAEA) in Vienna numerous plasma physicists from the U.S.A., U.S.S.R., Japan and the European Community (EURATOM) have been working out the principles for a joint toroidal fusion experiment, INTOR (International Torus). Parallel to these activities and in close conjunction with them, there is European cooperation on a possible successor experiment to JET, called NET

(Next European Torus). For this purpose a NET European study group is to be formed. IPP is interested in hosting this group.

The INTOR study group is taking stock of the data essential for a future large fusion experiment serving as a test reactor. Main problems will be the technology of the first wall and blanket and demonstration of the reliability of all reactor components. The boundary conditions for this concept are a maximum load of 1.3 megawatts per square metre on the first wall, a duty cycle of 70 % and an availability of up to 50 %.

In providing the head of the European INTOR study group, Max-Planck-Institut für Plasmaphysik not only contributes to the organization of the European effort for this work and to the maintenance of the European influence on INTOR development; it also handles very specific questions such as plasma initiation and shut-down scenarios, impurities, large current disruptions, effects of magnetic field fluctuations, and cost estimates. If approved, INTOR is scheduled to start operation in the mid-nineties.

5.5 Thermonuclear Burn in ZEPHYR

In the ZEPHYR ignition experiment, for which planning was carried out between 1978 and 1980, a plasma was to be confined with magnetic fields in a ring-shaped tokamak configuration and heated till the energy losses of the plasma were compensated by the energy of the alpha particles resulting from fusion of hydrogen isotopes. The nuclear fusion or burn process involved was to be maintained for up to five seconds. If successful, this experiment would have demonstrated the physical feasibility of the principle on which a fusion reactor was to work. After the initial impetus provided by the experimental results obtained in Pulsator at IPP and Alcator at MIT, it had been found in almost all tokamaks that the confinement behaviour of hot plasmas improves with increasing density, contrary to expectation. Furthermore, the Princeton Large Torus (Princeton, U.S.A.), a large experimental device comparable with ASDEX, had shown that plasmas can be heated to up to 70 million degrees by neutral particle heating, this being close to the temperatures required for a fusion

reactor. These results suggested that a burning plasma might already be achieved in an experiment small in relation to the reactor.

The ZEPHYR team, comprising about 40 scientists, therefore investigated various concepts for such a thermonuclear burn experiment. The different ways can be distinguished primarily by the methods used to heat the plasma. The most natural and cheapest heating method utilizes the ring current in a tokamak plasma, which is needed in any case to stabilize the plasma. Unfortunately, this heating method alone does not afford sufficient technical and physical reliability. This is because the hotter the plasma is the lower is its electrical resistance and the smaller is the heating effect of the flowing current. A different heating method thus has to be applied when high plasma temperatures have to be reached.

This is done by injecting beams of fast particles into the plasma, where they collide with the plasma particles. Their energy is thus converted to thermal energy (see Sec. 2.4.1). Since charged particles are reflected by the magnetic field and thus cannot penetrate into the plasma, they first have to be neutralized. The neutralization yield, however, drops very sharply above a particle energy of 150 to 160 kiloelectron volts. On the other hand, neutrals of this energy have insufficient penetration capability at the particle density and geometrical dimensions necessary for this experiment. A plasma of low particle density therefore has to be heated with the neutral beams and then subjected to adiabatic compression to put it in the parameter range required for ignition.

This concept formed the basis for a proposed experiment in which the plasma is heated in three stages. After the plasma is heated with the tokamak current, neutrals with an energy of 160 kiloelectron volts and a power of about 20 megawatts are injected into it. The plasma is then adiabatically compressed with a compression factor of 1.5, whereupon it forms a ring with a major diameter of 2.7 metres and a minor diameter of 1 metre. A magnetic field strength of 9 tesla on the minor axis of the plasma was aimed at. As great heat is generated, the magnetic field coils surrounding the ring vessel are cooled with liquid nitrogen to maintain the magnetic field for five seconds. The current in the plasma was to be more than three million amperes. At a density of up to 500 particles per cubic micrometre the temperature of the plasma was to rise to 150 million degrees. In the thermonuclear burn state ZEPHYR was thus expected to yield a fusion power of about 100 megawatts for about five seconds. About 1/100 gramme of the hydrogen isotopes deuterium and tritium is required to fuel a burn cycle. This quantity of tritium has a radioactivity of about 100 curies. As tritium is radioactive (half-time about 12 years) and highly volatile, ZEPHYR has to include special safety precautions such as remote control, hot cells, sluice systems and multiple shielding of equipment and buildings.

One of the aims of the ZEPHYR experiment was to demonstrate ignition of fusion: With more than a hundred particles per cubic micrometre the plasma is expected to ignite already after energy confinement times of less than a second. Furthermore, with a burn time of five seconds the ignited state can also be investigated for a multiple of the energy

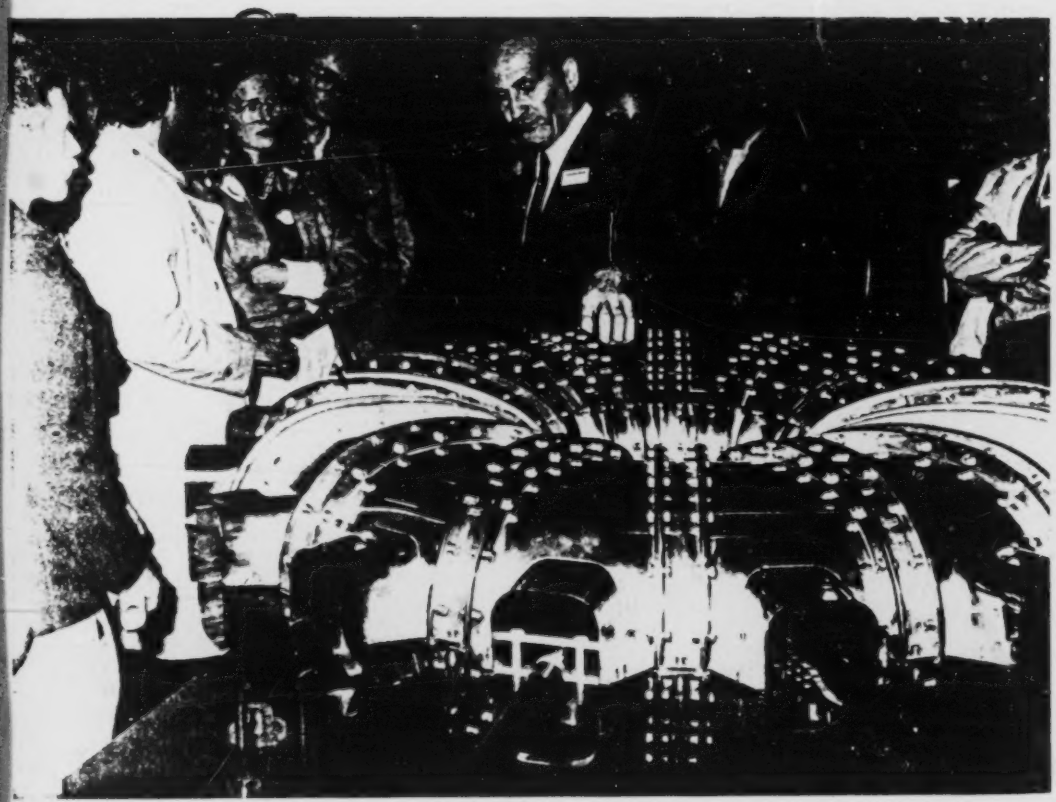


Fig. 45
The planned ZEPHYR fusion experiment (here a copper model of the vacuum vessel) was intended to demonstrate thermonuclear ignition and burn of the plasma as the physical basis for a future fusion reactor.

confinement time. It is only after several confinement times that major influences of the alpha particle heating, such as changes of temperature and density (and other parameters), can be measured and studied in the plasma. Alpha particle heating is an important objective because the introduction of new heating methods can completely change the behaviour of the plasma discharge, as in the case of neutral injection.

The wide parameter range aimed at in ZEPHYR was intended to allow optimum operating conditions to be defined for the future fusion reactor. Particular emphasis was placed on investigating to what extent a power reactor has to work in the thermally unstable regime, and what action is necessary to control the unstable working point.
The work on ZEPHYR was performed in close collaboration with MIT (Cambridge, U.S.A.) and supported by contributions from CNEN (Frascati), Lawrence Berkeley Laboratory (LBL, Berkeley), Princeton Plasma Physics Laboratory (PPPL, Princeton), Kernforschungsanlage Jülich, Kernforschungszentrum Karlsruhe and other laboratories, and numerous industrial enterprises.

After the budget cuts imposed by the Federal Government at the end of 1980 IPP was obliged to discontinue design work for ZEPHYR.

APPENDIX D

Design Features

What are the main fields of application of the HTR-Module?

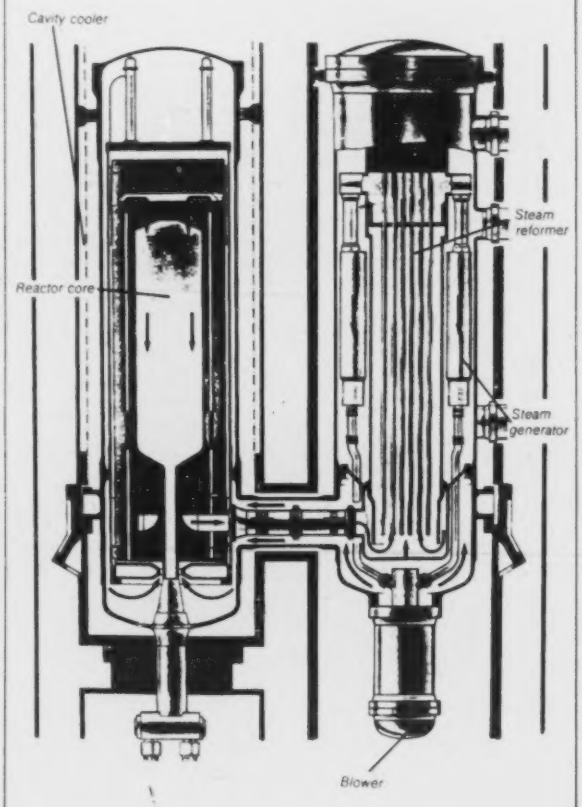
Its ability to produce heat at a high temperature level primarily points to its use as a source of process heat, e.g. for the refinement of coal, oil and natural gas. A further possibility: The production of process steam and district heating, which, coupled with the production of electrical power, attains high efficiencies even with small unit ratings.

The process heat demand varies over a wide range both with regard to the quantities required and the corresponding temperature levels. The disadvantage of the heat supply: In contrast to the electrical power supply, it lacks an extensive grid system that would allow compensation of plant outages. The consequence: The HTR is required to exhibit flexibility in the power rating combined with high availability.

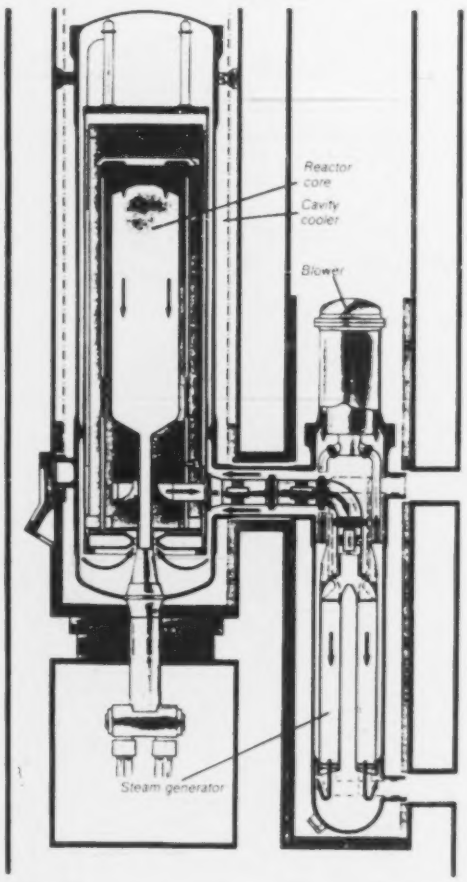
KWU/INTERATOM took account of these boundary conditions in the development of the HTR-Module concept. It is based on the already proven AVR and LWR technologies, the know-how collected during the development and construction of the THTR and experience gained from the operation of reactors and experimental facilities.

The HTR-Module concept was developed as follows: Standardized reactor units with low power ratings are combined to form plants in a wide power range. An HTR-Module unit has a power rating of 170 KJ/s for process heat production, whilst a rating of 200 MJ/s is typical for steam production at somewhat lower gas outlet temperatures.

HTR-Module with steam reformer



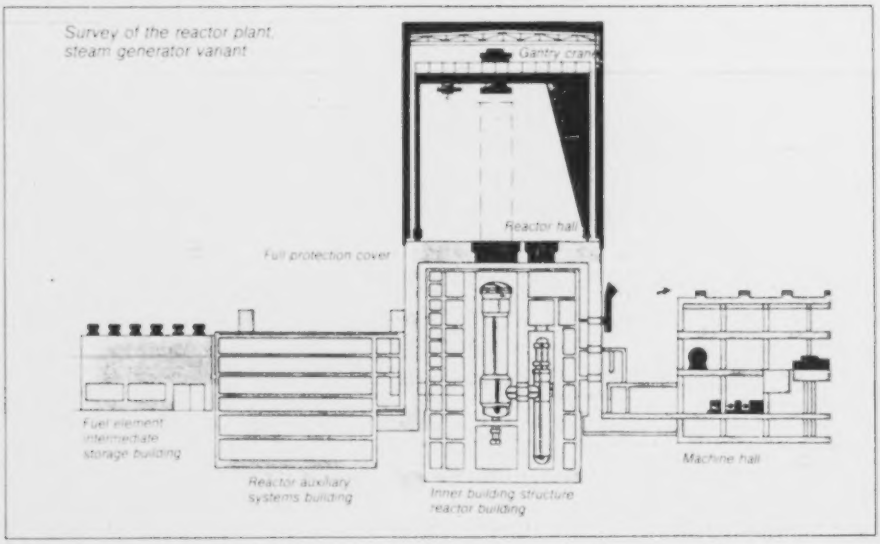
Layout principle and gas ducting of an HTR-Module with steam generator



The following system elements make up an HTR-Module unit:

- The pebble bed reactor with a thermal output of either 170 or 200 MJ/s at an average power density of up to 3 MW/m³. Its control and shutdown elements move vertically within the side reflector and it is equipped with facilities for fuel element handling. Helium flows downwards through the core.
- The steel pressure vessel containing the reactor.
- The heat transfer component, which may be a steam generator, a steam reformer with integrated steam generator, or an intermediate heat exchanger, depending on the purpose of the plant.
- The steel pressure vessel containing the heat transfer component.
- The coaxial gas ducts between reactor pressure vessel and the steel pressure vessel containing the heat exchanging component.
- The primary circuit helium blower which is attached to the steel pressure vessel containing the heat transfer component.
- The primary cells, two adjacent concrete cavities in the reactor building, separated from each other by a concrete wall. They house the reactor and the heat transfer system and are equipped with pressure relief systems.

Safety concept



The HTR-Module is a system, which combines the general HTR-specific safety properties with the particular safety advantages of small reactors. Its limited size, the low power density and the slim core design yield an extraordinarily high degree of passive safety.

A study performed by the TÜV Rheinland confirms that the module concept fulfils the German and international licensing requirements. A fast, streamlined licensing procedure may be anticipated because of the simple and clear-cut safety concept.

Safety analyses were carried out on:

- A large number of postulated reactivity accidents
- Failures of the main heat transfer system
- Primary and secondary pipe ruptures
- Radiological consequences of severe accidents

The temperature transients of high temperature reactors are extremely slow owing to the high heat capacity of the core and the graphite structures. This even applies to fast changes in the primary circuit heat balance. Even assuming extreme hypothetical accidents, there is ample time for engineered safeguards to react or for active measures to be taken to prevent or limit any potential damage to reactor components.

A fuel temperature of 1600° C was not exceeded in any of the accident combinations analysed. (The rapidly increasing release of fission products due to failure of the fuel cladding can no longer be excluded above this temperature.) Even assuming an extremely hypothetical situation: Depressurization of the primary system combined with a large water ingress and susequent heating up of the core. Proof of HTR safety. The dose rates in the vicinity of the reactor are clearly below the accident dose rate limits specified by the German Radiation Protection Ordinance.

Maintenance concept

As a consequence, the shutdown and decay heat removal systems, as well as the design of the buildings, have to fulfil much less stringent safety requirements. This leads to considerable simplification in the manufacturing and installation, in in-service inspections and in the proofs to be submitted to the Licensing Authorities.

Under normal shutdown conditions, decay heat is removed via the main heat transfer systems. However, only the operational aspects need be considered in their design, since, even in the case of their failure, the decay heat will be safely discharged from the core to the environment via natural convection, radiation and heat conduction through the steel pressure vessel and the cavity coolers.

Another marked simplification is the use of one single standard shutdown procedure for any type of disturbance, to bring the reactor into a hot sub-critical condition.

The concept of a pressure-tight containment may be abandoned in favour of a simpler depressurized shell (without any risks to the environment).

Calculations for a multi-module plant indicated that no safety problems will arise in connection with the start-up or shutdown of individual modules.

The reactor building is designed to withstand external impacts, in accordance with the standard licensing regulations.

One of the most important characteristics of the HTR-Module is its easy accessibility for maintenance work and repairs. Inspections or in-service inspections inside the reactor pressure vessel (exception: visual inspection of the reflector surface and the sphere discharge tube) are performed under hermetic conditions while the core is fully loaded. Examination of the reflector surface requires at least the partial unloading of the core, and complete unloading is necessary for the inspection of the sphere discharge tube. The space above the thermal shield is made accessible by taking off the cover of the reactor pressure vessel and mounting a shielded work platform. The necessary work can be performed manually from it.

After opening the reactor pressure vessel, the cold gas plenum, boreholes in the side reflector and the hot gas duct can be reached through inspection holes in the thermal shield, which are provided with isolating valves. During reactor operation, they are sealed off by the shutdown elements or by blind flanges. For inspection purposes, a TV camera system may be mounted tightly on the inspection hole and, after opening the corresponding isolating valve, it can be lowered into the region of interest. Decay heat removal via the main cooling system keeps the primary circuit at a low temperature during maintenance work. The necessary inspections of the heat exchanging components may also be carried out from the secondary side without having to open the primary circuit. The secondary systems (ducts, apparatuses) behind the isolating valves of the primary/secondary heat exchangers are subjected to inspections based on the rules and regulations for conventional plants.

Components subject to wear and aging, such as transducers, shutdown systems, fuel element handling equipment, as well as blowers with their flaps, may also be repaired or replaced under hermetic conditions while the core is fully loaded. The same applies to the replacement of the catalyst in the steam reformer or the plugging of steam generator tubes.

The fact that the core vessel, the heat exchanging components and the hot gas duct can be removed ensures the maintenance of all primary circuit components, if it is impossible to repair them in situ.

MODULAR HTGR POWER REACTOR

- REACTOR
  - HIGH TEMPERATURE HELIUM COOLED SYSTEM
  - TRISO FUEL PARTICLES IN PEBBLE FORM
  - THERMAL RATING APPROX 250 MW(t)
- SPECIAL DESIGN FEATURES
  - STEEL REACTOR VESSEL
  - ON-LINE REFUELING
  - NO CONTAINMENT REQUIRED
- PASSIVE SAFETY
- STANDARD (FOSSIL) POWER CONVERSION SYSTEM
- PERFORMANCE
  - 38% NET THERMAL EFFICIENCY

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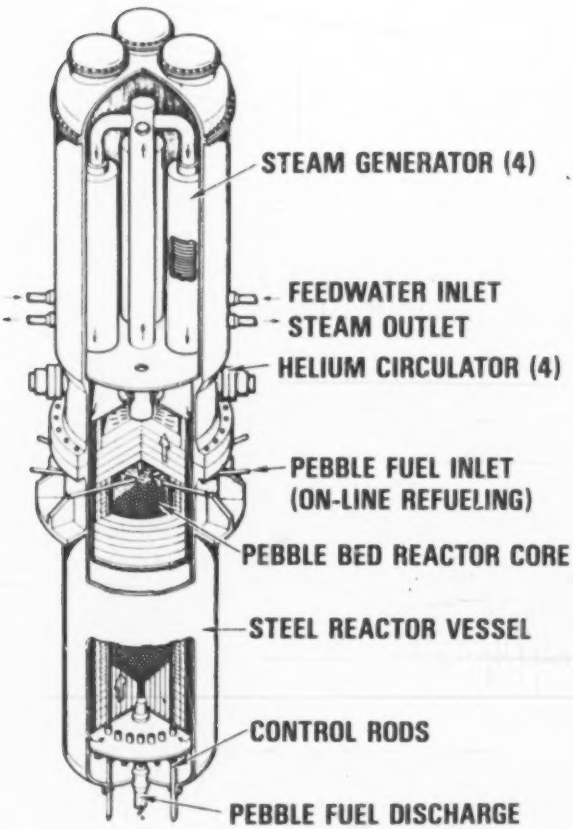

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MODULAR HTGR PARAMETERS

NUCLEAR HEAT SOURCE	
THERMAL POWER, MW(t)	250
HELIUM PRESSURE, PSIA	1050
HELIUM TEMPERATURE, ^{o}F	1270/541
POWER SYSTEM	
POWER CYCLE	NON-REHEAT
TURBINE STEAM INLET PRESSURE/TEMPERATURE, PSIA/^{o}F	2400/1000
SYSTEM	
NET ELECTRICAL OUTPUT, MW(e)	95
NET THERMAL EFFICIENCY, %	38

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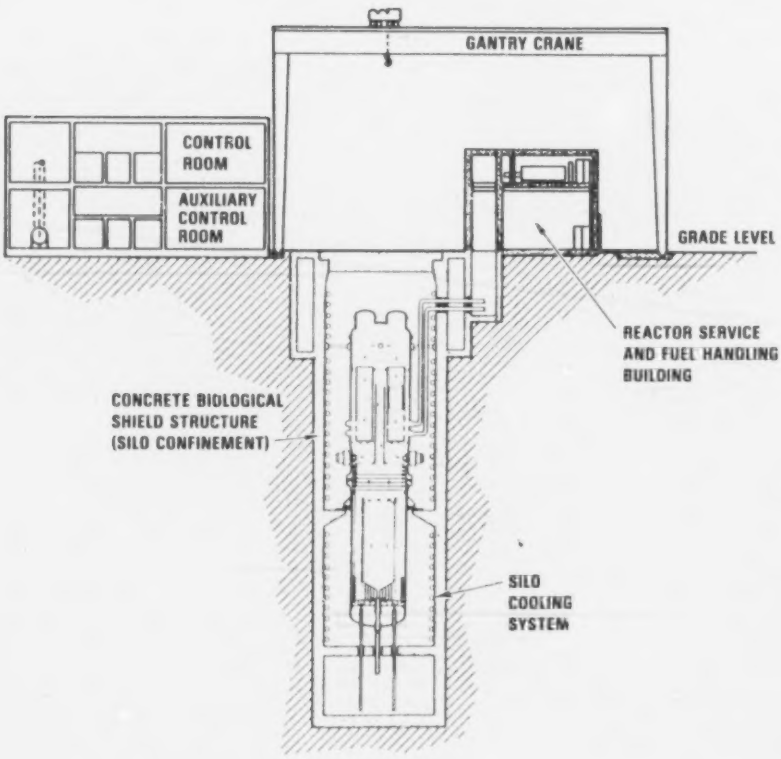
BELOW-GRADE SILO INSTALLATION OF MODULAR HTGR



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APPENDIX E

Introduction

The theme of this paper "Medium- and Long-Term Oil Market Developments" is of particular importance in view of the future challenges to the oil and gas industry. In the past two decades the oil industry has made significant technological progress, enabling it to move into deeper and more hostile physical environments and to uncover hydrocarbons in such complex geological structures as the U.S. overthrust belt. Throughout most of that period oil prices were stable or rose and the petroleum industry foresaw ever-growing future demand for oil and natural gas at steadily rising prices.

In recent years these assumptions have changed. Not only did the two oil shocks of the seventies reduce economic activity, but higher energy prices also sharply reduced the energy intensity of the Western economies. The trend towards ever-rising demand for imported oil which made the industrialised countries so vulnerable to supply interruption and price shocks in the seventies has been reversed - in particular since 1979. Higher energy prices and government policies have made improvements in energy efficiency and indigenous energy supplies economically attractive. In the ten years prior to 1984, the OECD countries have added some nine million barrels per day of oil equivalent to domestic energy production, almost equally divided between indigenous oil, coal and nuclear power. In the developing countries too, enhanced exploration and development in the seventies have resulted in considerable growth in oil production in non-OPEC developing countries. Between 1979 and 1984, oil production in non-OPEC developing countries rose by an astounding 3 mbd. While much of the growth was concentrated in Mexico, production rose steadily in a large number of other countries such as Argentina, Brazil, Egypt, India, Malaysia, etc.

Reduced dependence on imported oil has made the industrialised countries less vulnerable to oil supply interruption and contributed to the recent softening in prices. Energy security in the past decade has been enhanced through a determined policy of oil stock building and the willingness of IEA countries to extend the range of responses to oil supply disruptions by adding prompt and co-ordinated stockdraw as an effective and rapid means to restoring oil supplies.

Progress made to reduce oil supply vulnerability has not come cheap. The cost of the two oil supply interruptions on the world economy has not been fully measured, but it is clear that both generated adverse trends for the OECD economies for a period of three to five years each. Direct and indirect effects of the 1979/80 oil price increases alone, may have cost the OECD economies about five per cent of real income in 1980/81. Moreover, the costs associated with premature capital obsolescence and dislocations within the industrial sector and in particular the energy-intensive industries, have run into hundreds of billions of dollars.

Changes in the efficiency of energy consumption and in the fuel mix have been significant as shown in Table 1 and Figure I, but it is important to remember that progress was the result of large-scale investments in new energy supplies and energy-saving technologies. To maintain a balanced energy mix and avoid a possible repetition of the events of the seventies in the world oil market, it is imperative to maintain the momentum in energy conservation and in the development of OECD oil and natural gas resources.

Introduction

The theme of this afternoon's session "Oil and Gas Market Development - Impact on Offshore Market" is of particular importance in view of the future challenges to the industry. In the past two decades the offshore industry has made significant technological progress, enabling the petroleum industry to move into deeper and more hostile physical environments. Throughout most of that period oil prices were stable or rose and the petroleum industry foresaw ever-growing future demand for oil and natural gas at steadily rising prices.

In recent years these assumptions have changed. Not only did the two oil shocks of the seventies reduce economic activity, but higher energy prices also sharply reduced the energy intensity of the Western economies. The trend towards ever-rising demand for imported oil which made the industrialised countries so vulnerable to supply interruption and price shocks in the seventies has been reversed - in particular since 1979. Higher energy prices and government policies have made improvements in energy efficiency and indigenous energy supplies economically attractive. In the ten years prior to 1984, the OECD countries have added some nine million barrels per day of oil equivalent to domestic energy production, almost equally divided between indigenous oil, coal and nuclear power. Natural gas pricing and the economic slow down of the early 1980s caused production to decline in the same period, but more competitive pricing coupled with the economic upturn have resulted in substantial growth in OECD natural gas output last year. This trend is expected to continue this year.

Reduced dependence on imported oil has made the industrialised countries less vulnerable to oil supply interruption. Energy security in the past decade has been enhanced through a determined policy of oil stock building and the willingness of IEA countries to extend the range of responses to oil supply disruptions by adding prompt and co-ordinated stockdraw as an effective and rapid means to restoring oil supplies.

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economies about five per cent of real income in 1980/81 alone. Moreover, the costs associated with premature capital obsolescence and dislocations within the industrial sector and in particular the energy-intensive industries, have run into the hundreds of billions of dollars.

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APPENDIX F

1. EXECUTIVE SUMMARY

1.1 Introduction

The Governing Board of the IEA, on the suggestion of its Committee on Research and Development, commissioned a Technology Review of the Clean Use of Coal. Though there is abundant coal available at a favourable price compared with those of oil and gas, and though the IEA has encouraged substitution of oil by coal, there is concern that conversion to coal use in power stations and particularly in industry is being impeded by inter alia environmental difficulties. The aim of this review is to provide IEA governments and other interests with an assessment of technology, which is either available or is being developed, to enable coal to be used cleanly and with greater amenity. It also identifies ways in which barriers to the employment and development of technology can be overcome.

Coal is in fact not always a "dirtier" fuel than oil. High sulphur fuel oil, widely used in power stations, gives rise to more sulphur oxide emissions per unit electricity generated than almost any possible coal substitute. However the difficulty with coal use arises from its variable composition, its content of mineral matter and its solid form. In consequence:

- It is more difficult to remove pollutants like sulphur from coal than from oil;
- coal as a solid is less easy than oil or gas to transport, handle and burn; and
- in addition, coal contains greater amounts of ash so solid residues and particulate pollutants have to be handled effectively.

It is to be expected that the recognition by coal producers, users and the public of the possibilities of using coal in a clean way, as described in the present report, will reduce opposition to this use, and provide a positive stimulus to its further development.

1.2 Environmental Concerns about Coal Use

Concerns* about coal use (as opposed to mining) are currently mainly about emissions of air-borne pollutants from combustion. These are primarily:

oxides of sulphur (SO_x)
oxides of nitrogen (NO_x)
particulate material (including traces of heavy metals).

Small amounts of hydrocarbons and carbon monoxide can result from inefficient combustion, but are not an inherent difficulty of coal use. Specific problems for equipment maintenance may arise from chlorine and other corrosive elements. Ash from coal combustion also requires collection and use or disposal under conditions that avoid water pollution from leaching.

These concerns over air pollution are expressed through regulations directly or indirectly governing permissible emissions from coal-burning plant. In IEA countries the regulations are expressed in different forms and often vary dependent on the type of use and size of plant. In recent years regulations have generally become stricter, as countries have tended to adopt the practice of one or two leaders in legislation. The tightening process still goes on, and individual users contemplating converting to coal use are uncertain what will be required of them in the future.

It is important to recognise that pollution in one medium (e.g. air pollution) cannot be addressed in isolation. Action to control air pollution will usually result in a solid or liquid byproduct. So the suitability of a control technology depends on total impact, including the desirability of containing pollution close to the emitting source.

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* A fuller discussion of environmental concerns is given in COAL: Environmental issues and remedies: OECD Paris 1983

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Recent attention has focussed on controlling SO_x and NO_x because of their possible role in the formation of acid deposition with the claimed consequent damage to fish, trees, etc. Coal combustion is not the only source of SO_x and NO_x; SO_x from fuel oil combustion and NO_x from vehicle exhausts are produced in comparable amounts. However the encouragement of more widespread coal use implies a responsibility to address the question of how air pollution, particularly SO_x and NO_x, from coal sources can be minimised. It is important to recognise that the mechanisms by which emissions of SO_x and NO_x lead to acid deposition and its effects on the natural and man-made environment are not precisely known, and that a more detailed understanding of the role of these pollutants and their interactions is therefore highly desirable. As a result of the uncertainties stemming from this incomplete understanding of the mechanism of acid deposition, there is disagreement on the extent to which the use of particular technologies to reduce emissions will lead to a reduction in acid deposition. However the use of coal in combination with modern emission control technology does offer the possibility of a substantial reduction of SO_x and NO_x emissions into the environment compared with what has been the situation in existing plants using both coal and fuel oil.

Rather than attempt to offer a solution for acid deposition as such, this review describes how technology is available or is being developed to minimise the emission of pollutants – to the air, to water or to the ground. The review suggests likely limits of the ability of each technology to remove pollutants.

1.3 Technology Assessment Summary

Table 1 below lists the technologies that are either available or under demonstration to make coal use cleaner. They are divided into three approaches – pre-combustion preparation, control during combustion, and post-combustion control of pollutant emission.

These approaches are not exclusive, and environmental regulations will usually necessitate more than one approach. Because of the variety of coal quality (e.g. sulphur content can be as little as 0.5% in one coal and more than 4% in another) and of the regulations in force, the most economic combination of approaches will vary from circumstance to circumstance.

TABLE 1 **TECHNOLOGIES FOR MAKING COAL USE CLEANER**

	TECHNOLOGIES WHICH ARE COMMERCIALLY AVAILABLE	TECHNOLOGIES WHICH HAVE RECENTLY BEEN DEVELOPED	TECHNOLOGIES WHICH ARE IN VARIOUS STAGES OF DEMONSTRATION*
Pre-Combustion	Conventional physical coal preparation Low pressure gasification processes	Improved coal gasification for the production of clean fuel gas	Advanced physical coal cleaning
During Combustion	Modern stoker-fired and pulverised coal-fired boilers for industrial and utility applications. Shallow bed atmospheric fluidised bed combustion (AFBC) for small industrial applications. Combustion control to reduce the generation of oxides of nitrogen (NO_x).	Deep bubbling bed AFBC for industrial use. Circulating bed AFBC for industrial use. Low NO_x burners for new utility and industrial boilers.	Coal Liquid mixtures. Advanced coal gasification. AFBC for utility use. Pressurised fluidised bed combustion (PFBC) for utility use. Low NO_x burners for retrofit. Furnace sorbent injection for the removal of sulphur dioxide.
Post Combustion	Electrostatic precipitators for utility and large industrial use. Fabric filters for utility and industrial use. Wet lime/limestone flue gas de-sulphurisation (FGD) for utility and large industrial use. FGD using sodium alkali sorbent.	Spray dryer FGD for utility and large industrial applications. Regenerable FGD with by-product recovery for utility applications. Selective catalytic removal of NO_x. FGD using ammonia sorbent.	Furnace sorbent injection for the removal of sulphur dioxide Dry sorbent methods of SO_2 and NO_x removal. Direct injection of alkaline sorbents.

* There are many other technologies, such as chemical coal cleaning, which are in various stages of laboratory development.

For example a regulation that prescribes or implies a maximum allowed level of pollution emission leaves the user free to choose the means of compliance to suit his circumstances. In some cases, for example, use of low sulphur or washed coal without further control might be the cheapest option for control of sulphur emissions.

If however the regulation specifies in addition that, for example, 80% or more of sulphur has to be removed from the coal, the user is more constrained. Add-on pollution control equipment, such as flue gas desulphurisation, may well be required, and usually the costs of compliance will be greater than in the first case. In addition, the progressive tightening of environmental regulations also carries a penalty. Prospective users cannot be certain what standards have to be applied, particularly if there is a chance that legislation will apply retrospectively. So a potential coal user either has to play safely (and more expensively) in his choice of equipment, or more likely he puts off a decision to convert to coal use in the hope that environmental standards will stabilise in the future.

The remainder of the summary comments on the status and development needs for coal technologies listed above.

Coal Preparation

— Environmental pressures are providing a new impetus to reassess coal cleaning, as a way of removing a moderate amount of the sulphur present in coal as well as the mineral matter. However, the extent to which sulphur can be removed depends on the inherent properties of the coal, including how much sulphur is chemically bound into the coal molecule and therefore cannot be physically separated.

— Before the practical limit, for a particular market, of sulphur reduction by physical coal cleaning can be ascertained, more information is required on the way the sulphur is distributed throughout the coal.

— Coal cleaning may contribute to improved boiler performance by providing a more consistent fuel of lower ash content to the boiler. There are several cited examples, suggesting that more systematic cleaning will generally pay for itself in savings from boiler performance. There is considerable scope for international collaboration on coal cleaning followed by combustion tests to determine the extent of improvements in combustion performance and reliability which can be attributed to the use of cleaned coal.

— Physical "deep cleaning" aims to remove pyritic sulphur and mineral matter by cleaning methods applied to finely ground coal. Subsequent use of coal in solid form necessitates dewatering and recovery of smaller particles of coal. The intensity of coal cleaning is also limited by the consumers' ability to handle, transport and use very fine coal sizes and the disposal of the by-products of deep cleaning. Some of these problems may be alleviated by the development of coal liquid mixtures.

— Coal liquid mixtures (CLM) offer the possibility of more extensive substitution of coal for oil in existing equipment. CLM may offer a means of using finely ground "deep-cleaned" coal, but probably will still need controls (during or after combustion) to meet environmental standards. The application of CLM in furnaces designed for oil may involve significant derating or reduced reliability in some cases, and continued demonstrations are required to quantify this.

Coal Conversion

— As an extreme form of pre-combustion treatment, the conversion of coal to gas or liquid fuels offers the possibility of using coal cleanly. The continued development toward commercialisation of modern gasification processes to produce fuel gas, or for the potentially important combined cycle generation of electricity, needs to be supported by the provision of suitable demonstration plants. Coal liquefaction remains a long-term option, which has strategic and security implications for transport fuel production rather than as a means of using coal cleanly.

Control of Pollutants Formed during Combustion

— Stoker fired boilers for industrial use, and pulverised coal-fired boilers principally for utility applications, have been in widespread use for many years and have reached an advanced stage of development as far as efficiency and ease of operation are concerned. Increased automation of these units and the use of better particulate control methods have improved their operation and environmental acceptability.

— The formation of NO_x in coal boilers can be limited by careful control of combustion conditions, including staged combustion to lower the flame

temperature. Much of the NO_x formed during combustion comes from nitrogen bound into the coal molecule and to control this, extensive burner modifications are required. Large scale demonstrations with new burners have achieved substantial reduction in NO_x formation, but wider demonstration is required.

— The development of staged combustion may also facilitate a method of removing SO_x which could be relatively low cost and particularly attractive for existing pulverised coal-fired plants. With staged combustion or other methods of reducing flame temperatures, injection of an alkaline sorbent may enable significant sulphur capture during combustion. There is concern, though, that such injection might not be able to remove more than half the sulphur present in the coal, and further development and demonstration are needed to establish the performance and reliability of this approach.

— Fluidised bed combustion offers several potential advantages in meeting the environmental requirements of coal use. It largely eliminates dependence on pre- and post-combustion clean-up processes, since it is possible to achieve a high level of SO_2 removal. NO_x emissions are low, and it is relatively insensitive to coal type. Further experience is now required to demonstrate these advantages relative to current technologies, particularly in overall economic impact.

— Fluidised bed combustion at atmospheric pressure (AFBC) is being introduced on an industrial scale and scaling-up for utility applications is underway. Reductions in cost compared with conventional equipment have not yet been realised, but are expected in future installations.

— Fluidised bed combustion under pressure (PFBC) is at an earlier stage of development. In principle it offers additional advantages of increased environmental control and reduced unit size. One application of interest is the possibility of constructing factory-built modular utility boilers which could be rapidly installed. Another is the incorporation of PFBC in the combined cycle generation of electricity, leading to higher conversion efficiency.

— If PFBC is to make a contribution, progress with pilot plants and experimental facilities needs to be maintained in order to ensure the transition to large scale.

Control after Combustion

— Flue gas desulphurisation (FGD), largely by wet scrubbing with lime or limestone, or occasionally with sodium alkali or ammonia, is the only currently available method for removing a high proportion of the sulphur oxides which are formed during the combustion of coal. Over 100 large plants are operating successfully in several countries. However, costs and difficulties of operating a chemical process in conjunction with combustion remain of some concern. These problems have been reduced by improved knowledge of the chemical processes involved, and FGD now poses fewer technical problems for new installations. The process leading to the production of gypsum has become the wet FGD system most frequently chosen. Retrofitting FGD, especially to older power plants, still causes difficulty, mainly because of limitations of space and other incompatible design features. Also flue gas desulphurisation is particularly expensive for smaller plants.

— Several processes also exist for regenerable flue gas desulphurisation, whereby sulphur or sulphuric acid are produced as a by-product. These processes are more complicated and costly than the "throwaway" by-product processes, and have not been anything like so widely installed. Newer regenerable processes may be more attractive in the future. Dry sorption with active carbon, in particular, has the advantages of capturing NO_x simultaneously and of avoiding the need to reheat flue gas.

— Spray drying with lime as a method of flue gas desulphurisation is being developed widely. The technology seems to be up to 30% cheaper to install than conventional wet limestone scrubbing. However a consensus on the overall economics, including sorbent efficiency and cost, has yet to be established.

— Highly efficient particulate removal is achieved using electrostatic precipitators or fabric filters. Additional areas of investigation are the increasing requirement to remove extremely fine particles, and the impact on the design and performance of particulate control devices resulting from methods used to reduce SO_x and NO_x emissions.

Waste Disposal

— Efforts to increase the efficiency of air pollution control equipment also have a significant impact on the control of solid and liquid wastes.

— The solid wastes would not normally be regarded as hazardous nor are the costs of disposal currently a major element in coal use. However the increased production of wastes, and trends towards increasingly stringent control with resultant higher costs, will provide an added incentive to develop usable byproducts, or to adopt control technologies that produce a usable residue.

— In many cases, methods have been developed for the recovery of usable byproducts. However some problems associated with wider use of solid waste may require special measures, and possibly government pressure. For example it may be desirable to encourage a variety of approaches to flue gas treatment so as not to saturate the market for any one type of waste byproduct. In general, materials standards may require review to prevent unreasonable discrimination against waste byproducts compared with traditionally-extracted materials.

1.4 Concluding Remarks from the Review

Several points emerge from this review of technologies for clean use of coal.

1) Firstly, technologies and processes do already exist to enable coal to be used sufficiently cleanly to meet current and likely future environmental standards. They include:

   — conventional coal preparation methods;
   — automated coal handling and boiler control;
   — precipitators and filters for particulate capture;
   — flue gas desulphurisation processes for sulphur removal; and
   — NO_x reduction or removal by control of the combustion process or by flue gas treatment.

   All are established for new power station use, but (aside from coal preparation) less well developed for retrofit to existing utility plants or for industrial use where the relative investment and operating costs are much higher.

Coal preparation (to remove some ash and sulphur) will often have a part to play to complement controls during and after combustion. The right balance of coal preparation with the other control technologies is likely to be individual to plants and types of coal.

2) The barrier to wider use of existing processes is largely their cost. Full control (i.e. to control SO_x, NO_x and particulates) on new power stations may increase the cost of generating electricity in these plants by around 25% (or more for high sulphur coal), relative to the cost for plants without controls. The cost increase will be more for industrial heating boilers. Of this the largest share is usually for flue gas desulphurisation (up to about 15%). It is even more expensive to have to fit controls subsequently to older plants designed for use without them.

3) There are many processes being developed trying to increase the efficiency of pollutant capture or to reduce cost. As a result:

— flue gas desulphurisation may become somewhat cheaper and more readily integrated with electric power plant and large industrial boilers.

— control methods for use during combustion (such as limestone injection and burner modification) could give control at much lower costs, with a large proviso that they can be developed to achieve acceptable levels of pollutant capture. Such methods typically have limited pollutant capture and their use needs to be seen as *part* of the whole system of preventing and cleaning up pollutants.

— fluidised bed combustion, which offers control during combustion with only a requirement for subsequent particulate control, should become increasingly important, particularly for industrial use and for cost effective modular addition of power capacity. However its potential for improved reliability and for cost reduction compared with conventional technology is still to be fully demonstrated.

— the use of coal water mixtures enables coal to replace fuel oil more easily in boilers and provide a cheap insurance policy for fuel supply. However it may require expensive preparation or post-combustion control. The economic competitiveness depends on several other considerations as well, such as the amount of boiler derating, as well as the price of oil.

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4) The near term goal of these technology developments is to make the clean use of coal cheaper. They will not provide a panacea, nor will there be an enormous reduction in the cost of control from the technology which will become available over the next few years. But there are useful savings to be made, and desirable increases in reliability and flexibility of control processes.

5) Most of the technologies for the control of air pollution give rise to increasing quantities of solid wastes, to be used or in many cases to be disposed of. It is to be expected that the quantity of solid waste from coal used will be perceived as a more serious difficulty than in the past, particularly in the need to avoid water pollution. This may alter the balance of desirability between pollution control technologies.

6) In the longer term there are hopes for technology, particularly for use with power generation, that will provide effective pollution control while increasing efficiency. This may lead to a reduction in the cost of power generation compared with today's cost of generation in power stations without pollution controls. Examples are the development of pressurised fluidised bed combustion and the use of coal gasification, both integrated with the use of combined cycle technology. However these kinds of technologies require substantial development support now if their future promise is to be realised. Especially there is a need for demonstration plants to ensure that suppliers and users can be confident about reliability and performance before commercial generation can take place.

APPENDIX G

"ENERGY TECHNOLOGY POLICY"—
INTERNATIONAL ENERGY AGENCY

EXECUTIVE SUMMARY

INTRODUCTION

In May 1983, IEA Energy Ministers assessed world energy requirements and security for the next two decades, bearing in mind the importance of adequate and secure energy supplies for the prospects for sustained economic growth, and noted with satisfaction the progress that had been made since 1973 in reducing dependence on imported oil by increasing energy efficiency and increased use of alternative fuels, notably coal, gas and nuclear energy. They agreed, however, that the relief provided to the world economy by the lowering of oil prices was likely to be temporary and that there remains a risk of a renewed energy constraint on growth unless the industrialised countries strengthen their policies to restructure their energy economies.

Energy research, development and demonstration policies will have a decisive impact on this restructuring. The Energy Technology Policy Study was undertaken to provide a basis for decisions which will materially affect long-term energy security – broadly defined as an adequate supply of energy at a reasonable cost – within IEA economies.

In particular, energy security can be enhanced by timely energy RD & D efforts to implement the following policy objectives. Government policies should be designed to:

— safeguard their economies against damaging world-wide competition for supplies of oil and gas;

- protect themselves from supply interruptions through diversification of fuel sources and supply technologies;
- promote the rational and efficient production, processing, distribution and use of energy;
- ensure that energy is supplied and used in a manner consistent with the protection of the environment and public health and safety;
- encourage the generation of, and provide access to, the basic technological knowledge and competence which will provide long-range energy options;
- allow the best allocation of world-wide energy resources and the development of strong, flexible energy systems; and
- take into account the lessons learned from the failure of structural adjustments in the 1960s and 1970s which lead to supply overcapacity.

Present perceptions of the energy situation for the forseeable future are substantially different from those of the mid-seventies when major energy RD & D programmes were undertaken in response to the first oil shock of '73. Accordingly, RD & D objectives must reflect the changing energy and economic environment. While they must in many cases be addressed to the long term, they cannot ignore pressing current concerns such as the mitigation of environmental impacts caused by energy use. They must also be predicated upon recognisable and accepted criteria, and be relevant to the needs of individual country circumstances.

General belt-tightening by both governments and the private sector impinges on most economic activity but is often particularly severe in its effect on RD & D, which is perceived by financial managers as marginal and easy to put aside temporarily to reduce expenditures which may not result in measurable achievement in the short term. While understandable, this reaction runs counter to long-term interests of both energy security and economic prosperity – it should be avoided in prudent planning. The current market conditions for oil should be viewed as providing an opportunity through RD & D to reduce future energy system vulnerabilities. The restructuring of energy economies requires a sophisticated and extensive technology infrastructure, both on the supply and the demand side. An essential condition of continued support for energy RD & D is that the investment be made wisely. The present study aims to assist this process.

PURPOSE OF STUDY

IEA countries have an annual combined public sector outlay of more than US$ seven billion on energy RD & D. General budgetary stringency combined with a more market-oriented approach to technology development makes it unlikely that this total will increase, while the progress of certain technologies from early to more advanced stages of development will place increasing demands on financial support. It is pertinent to ask whether these considerable sums are being invested in a manner consistent with the energy security objectives of IEA countries, bearing in mind the inherently long-range nature of much of the research effort and the continuing need for energy security beyond the end of the century. The Energy Technology Policy Study has sought to examine the nature of energy research investment in IEA countries. In particular it has sought:

— to identify issues, and when possible draw conclusions, which will assist policy makers in reviewing their portfolios of energy RD & D activities and making investment decisions for perhaps the next five years, which will significantly influence the direction of technological development for the appreciable future;

— to draw on the experience of ten years of IEA activity and a considerable body of detailed analysis to provide some insights into the formulation of energy technology policy;

— to explain how technology can contribute to national goals for energy security, economic performance, improved capability, and ecological preservation;

— to identify impediments to those energy technologies that could contribute most immediately to the policy objectives identified above, and to the IEA nations' future energy supplies; and

— to promote the adoption of technical and policy approaches for the mitigation of such impediments.

STRATEGIC APPROACH TO ENERGY TECHNOLOGIES

The term "Energy Technologies" embraces a diverse and disparate collection of activities. For purposes of strategic thinking about future energy system development, there are two basic categories of energy

technologies: those which are intended to increase or diversify supplies of energy and those designed to reduce demand for energy or to make its use more efficient. Some are relatively simple in concept, others involve combinations of highly sophisticated machines and processes. Some involve the more prosaic needs of the householder; others respond to the requirements of complex electricity undertakings. Some are short-term in their potential application; if successful, others may affect life-styles sometime into the next century.

CRITERIA FOR ENERGY RD & D INVESTMENT

The IEA countries are not a homogeneous entity – their social and political situations, their overall and energy economies, and particularly their indigenous energy resources, are diverse. It follows that their energy RD & D requirements, and their capacities to address those requirements, will be equally diverse and must be tailored to national perspectives. Taking energy security as the pivotal concern, there are certain additional common criteria which all IEA countries will want to satisfy in designing their national and international energy RD & D policies. These common criteria concern:

— *timing:* the timing of the potential contributions to be expected from each given technology and of the need for those contributions;

— *competition among technologies:* the degree to which different technologies will be in competition with each other;

— *project effectiveness:* the effectiveness of individual RD & D projects, including considerations of minimum useful size, rate of progress, and ability to implement results;

— *international collaboration potential:* an appraisal of the more efficient use of available resources by sharing risks, costs and benefits through international collaboration;

— *benefits vs. costs:* the degree to which the benefits from a given technology seem commensurate with the costs of its development; and

— *environment, health and safety concerns:* the degree to which pursuing energy technology advances is consistent with environmental, health and safety concerns.

ENERGY RESEARCH – GOVERNMENT AND INDUSTRY

IEA countries generally recognize that the market mechanism will be the most important and appropriate determinant of which new technologies are implemented, and when. However there are limitations, which also vary widely from country to country, on the extent to which market forces can be relied upon to develop appropriate solutions in a timely fashion, particularly when national interests are concerned. These national interests may include:

— national energy and economic security, including the ability to withstand disruptions in energy supply;

— health and safety research and regulation;

— environmental concerns;

— provision of an adequate technology infrastructure to support long-term future industrial applications;

— employment, industrial and regional development; and

— defence.

All of these factors require some continuity of long-term purpose during the fluctuating short-term pattern of energy market incentives. Each of them points toward some degree of government-sponsored energy RD & D. None can be adequately handled solely by the private sector, for government alone ultimately bears these responsibilities.

Under the influence of market forces, industry can be expected to invest in energy RD & D if:

— there is an established technical base to support further technological development;

— the chances are reasonably high that the effort will result in a useful product;

— the resulting product is expected to be economically competitive and a reasonable market exists; and

— the time to commercial penetration of market and the pricing potential allow acceptable returns on investment.

As a consequence of differing government and industry interests, energy RD & D supported by each may not coincide and technologies

promoted by governments may not meet industry criteria. A smooth transition between the two cannot always be expected, and policies may be necessary to overcome these differences.

ENERGY SECURITY – VULNERABILITIES ASSOCIATED WITH LIQUID FUELS

The IEA Energy Requirements and Security Study of 1983 stressed the vulnerability of IEA economies to interruptions in supplies of both oil and gas. It might be assumed that the priority established for these fuels in terms of energy security would somehow be reflected in government energy RD & D investment for these fuels. This does not appear to be the case – about three-quarters of the total investment is devoted instead to electricity-related technologies. This seemingly large imbalance does not by itself constitute an over-emphasis on electricity since ensuring an economic electricity supply for the future is itself an imperative for future economies. Thus the investment into the electricity sector seems appropriate. Rather, the apparent imbalance seems to stem from a lack of emphasis on liquid fuels in government programmes, both synthetic alternatives to oil and the means of extending present resources of oil and gas by more efficient exploration, extraction, distribution, and utilisation techniques. In many cases this reflects deliberate policy since there exists considerable private sector RD & D activity in these areas. However, private sector activities are not undertaken to serve the governmental objective of liquid fuels security, and it is the future energy security issue rather than the present competitive position of the product which may require a more deliberate policy approach on the part of government.

The vulnerabilities of economies to shortages of liquid fuels, so fundamental to the transportation sector for the forseeable future, pose a dilemma for government in terms of RD & D. By virtue of the existence of a highly developed, knowledgeable, and financially astute industry, RD & D in oil technology is heavily in the domain of the private sector. Despite its enlightened attitude, it is important once again to emphasize that industry does not have the same energy security responsibility as government. Pragmatic considerations of return on capital invested and the desirability/cost of a product in a highly competitive market may lead industry to have shorter horizons for energy RD & D investment than do governments concerned about the economic security of their countries.

In these circumstances, governments should consider action in two areas:

— to ensure that available resources of oil and gas are developed to the maximum extent possible. This can be assisted technologically by strong support to basic science and applied technology in the geo- and material sciences which impact exploration, drilling and production techniques and enhanced oil recovery; and

— to develop alternatives to conventional oil and gas, for example by coal liquefaction, coal gasification, coal-liquid mixtures, oil shale, tar sands, gasoline from natural gas, and alcohol fuels from biomass. While governments differ on their perceived role in demonstration scale activity, this does imply a concentration of effort on basic processes, catalysts, materials, and component design together with process development at least up to pilot stage.

ENERGY SECURITY – DIVERSITY

The IEA Energy Requirements and Security Study also indicated the importance of diversity of supply to energy security, by reducing the potential impact of interruptions of any single source and by providing additional options for its replacement. Electricity presents a distinct advantage in this context, both through its ability to displace other energy sources in end use and through the flexibility inherent in the diverse generating fuels and technologies. Thus what may appear to be duplicate or even competing technological approaches towards achieving a particular energy supply form, e.g. liquid fuels or electricity, may in fact be contributing significantly to the diversity aspect of energy security. Similarly, development of renewable energy technologies is likely to have a significant role in the longer term in promoting national strategic advantages in diversity, since they present a broad range of indigenous energy supply options.

ENVIRONMENTAL CONCERNS

IEA governments are mindful that however dominant energy security may be for safeguarding economies in the future, this security cannot be achieved at the expense of environmental degradation – a careful and deliberate balance must be maintained. The short-term development of

energy technologies must thus be directed towards ways of ensuring that the contribution of coal and nuclear power to energy supply is environmentally acceptable. The contributions of technologies making the use of energy more efficient and of renewable energy technologies to overall environmental quality should also be taken into account in determining this balance, particularly in the longer term. In future energy technology development, more attention will be required to ensure that technical, economic and environmental aspects are properly incorporated early in planning so that environmental problems do not undermine otherwise valid expectations about the evolution of the energy system.

POLICY ISSUES WITHIN THE TECHNOLOGY AREAS

In order to discuss energy technologies with such a wide range of characteristics, it is convenient to consider these technologies according to the degree to which they:

— use available energy more efficiently;

— expand the use of conventional fuels by:
  . extending the useful lifetime of resources of oil and gas;
  . removing impediments to the full and safe utilisation of alternatives to conventional oil and gas, particularly coal and nuclear;

— promise to contribute in the longer term to energy supply, such as breeder technology, synthetic fuels and fusion energy; and

— enable the use of renewable energy sources.

The rational use of energy, *or end use efficiency*, is an essential ingredient in keeping energy supply and demand in balance and thereby resisting upward pressure on prices. A recurrent theme in this study is that considerable additional energy savings can be made by applying those technologies already demonstrated, but whose merits and potential need wider dissemination. Notwithstanding impressive gains, R & D can add still further to achieving improved use of energy sources for it is the driving force behind new ideas and applications. Investment in development of energy efficient technologies is a rapid and cost effective way of complementing the more difficult task of creating additional supplies from existing or alternative sources, particularly as the latter will tend to be more expensive than present day supplies of conventional

fuels. Thus the active encouragement by governments of conservation measures and conservation research is likely to continue to produce significant dividends.

Oil and to a lesser extent *gas* continue to dominate energy use in IEA countries and the vast infrastructures in place for producing, transporting and marketing them underline the likelihood of their ongoing importance and the necessity of discovering and producing these resources to the maximum extent. Improved exploration and drilling techniques and, particularly for offshore resources, advances in design and maintenance of offshore structures are necessary to permit fullest resource recovery. Enhanced oil recovery (EOR) technologies make possible the production of substantial additional amounts of oil, not extractable through conventional methods, from existing oil fields by injecting steam, CO^2, gas and flooding agents into the oil-bearing deposits. While responsibility for the development of these technologies has historically been that of the producers, governments are increasingly aware of the impact of EOR development on the formulation of their depletion and oil leasing policies and on security of oil supply.

Coal resources will outlast all other fossil fuel resources – they are more extensive and are better distributed within IEA economies than all other fossil fuel supplies. Coal is a resource both as a combustible fuel and as a feedstock for the petrochemical and synthetic fuel industries. By comparison with oil technologies, its use has been relatively unsophisticated, its RD & D relatively neglected. If it is to realise its full potential in IEA economies, its combustion or conversion must be achieved so that pollutants are minimised. Not only must the environment be safeguarded but it is important to ensure that the pollutant removal process before, during and after combustion imposes a tolerable financial burden on society – it must be affordable and easy to maintain. Combustion processes should minimise the formation of oxides of nitrogen and sulphur. Governments should give the highest priority to the remedial technologies for air pollution abatement. Basic coal sciences are increasing in sophistication, and as they do so they will open up a wider range of possibilities for its use. Productivity, safety, and efficiency of mining operations also remain key factors in the use of coal.

The abundant resources of coal can further be used in the production of synthetic alternatives to oil and gas through the various technologies for coal liquefaction and gasification. In the development of these technologies, attention must also be paid to ensuring environmental

acceptability. An abundant supply of fossil fuel resources is also contained in *tar sands and oil shales* – they are more abundant than normal oil and gas reserves but less than coal. They exist in many IEA countries. While interest revived in these resources in the '70s, it diminished in the '80s under the growing realisation that the product would be expensive at a time when oil prices were not anticipated to continue rising. Thus governments face the dilemma posed by *synthetic fuels* generally, namely how to increase the viability of the option presented by these resources through well-directed research leading to a firm and sophisticated technology base without necessarily proceeding to the commercial or even demonstration scale. This is a major policy challenge.

Since *nuclear power* for IEA countries as a group is a key ingredient in a balanced electricity supply system and potentially as a source for district heating, thereby further reducing dependency on oil and gas, its degree of penetration into the market is a source of continued concern. Concerns about the health and safety aspects of reactor operation, waste management and ultimate disposal have led, in some countries, to fears that it will be unable to play the full role its potential had previously indicated. Its failure to do so could have serious consequences. These concerns can only be assuaged by a continuing and convincing record of both safe operation and sustained progress on the major issues of public concern translated into appropriate legislation and regulation. Public confidence in the ability and will of their governments to protect their interest in the health and safety aspects of nuclear power will as much determine its future market penetration as will its economics. Governments will have to decide and begin to take action on development of national nuclear waste management strategies, giving consideration to an international component. Further developments are also expected with respect to advanced thermal reactors, including compact light water reactor core designs, improved high temperature gas cooled reactor (HTGR), all of which may lead to improved cost and operational performance for the next generation of nuclear power plants.

Breeder technology holds different prospects for different countries. For some countries, not richly endowed with indigenous energy resources and reliant on imported fuels, it offers the prospect for the first time of an indigenous fuel source and the opportunity to be less beholden to imports – in a word, it is a matter of their energy supply security. This is not necessarily the view of governments whose countries are presently better endowed with natural energy resources. Present economics of breeder technology which currently dominate the thinking in several

countries do not compare favourably with those of the current generation of nuclear reactors. Research must be directed towards lowering the cost and ensuring commensurate health and safety in the operation of breeder reactors. The prospect of extending the effective life of uranium over many hundred years, the avoidance of vulnerability to imports and the possibility of reduced generating costs will, however, continue to make breeder technology development an attractive option in many countries.

Fusion power, unlike conventional nuclear power or even breeder technology, remains as yet unproven as a controlled energy source. The achievement of a sustained fusion reaction through intense magnetic confinement remains the future challenge for fusion energy research. Once a sustained thermonuclear reaction has been achieved, further major challenges will be faced in successfully engineering the technology to the point of practical application. While the present generation of machines are important steps along the road, they will need to be followed by other equally important steps in the next decade before it can be said with conviction that an energy option is truly available. Decisions on the next steps, based on the lessons from the present research, will require much thought and debate. Governments will be faced with forceful arguments and difficult choices involving large investments. They should not however lose sight of the immense potential this technology offers even in light of the imponderable obstacles and the long time frame which confronts them. The technical evidence presently points in the direction of success, and to do other than to support the technology to the point of proof of technical feasibility would not do justice to future generations. The point of proof will be roughly at the end of this century: governments should not reduce their support at this time below a level where this proof cannot be reasonably achieved. They should also consider, on an urgent basis, the possibilities afforded by enhanced international co-operation to reduce their financial burden and utilise resources more efficiently.

Renewable energy sources may be important regionally, especially for those economies which possess few other indigenous resources. With the exception of well-established hydropower, fuelwood and geothermal, however, they do not promise a major contribution to the energy supply/demand balance within this century when considered over IEA countries as a whole. Taken together, the full range of renewable energy sources represents a very large potential – if only a small fraction of this potential were to be realised, the contribution would materially affect the energy supply mix of IEA countries. The financial structure of

the present renewables industry is typical of a new and emerging industry – its capacity to engage in RD & D is quite limited and many of its current products are not economic without favourable incentives for introduction. The past ten years of experience have largely narrowed the range of technologies being pursued to the most promising, and governments should support those technologies which can harness their natural resources of sun, biomass, wind, wave and geothermal energy reliably, economically and in an essentially benign manner. The long-term nature of this endeavour should be re-emphasized, and sustained government support for its development will be required to realise its potential – the corollary is that the investment should continue to be sharply focussed.

The "*technology base*" embodies those scientific principles and interdisciplinary issues that nourish the development of ideas for later specific technology applications. While such research has proceeded vigourously in the nuclear fission and fusion sectors, concomitant efforts in the basic sciences related to coal, energy saving and renewables have not been forthcoming. The process of combustion, for instance, is a highly complex mechanism which was poorly understood before the advent of modern diagnostic techniques born of sophisticated laser technology – the consequences of this understanding will be far reaching. There is a similar need to improve the understanding of the behaviour of materials – in many cases technologies are limited in their progress simply by the lack of appropriate materials. The pay-off in one sector from an investment in another is a recurrent feature of modern science. The investment can be relatively modest, but the leverage great. Governments should ensure that the natural desire to see a technology enter the market place does not divert attention from the continued generation of those ideas from which technological development stems.

Energy storage contributes significantly to flexibility and diversity of supply – energy can be produced at one time for use at another. Perhaps the most pressing technical need is for large-scale electricity storage: pumped storage in hydroelectric plants is already employed in many countries where economically justified, but its site-specific nature and relatively poor net energy recovery factors indicate the need for new technologies. Improvements in battery storage could assist in this objective and are clearly a prerequisite for significant penetration of electric vehicles, which will also affect the balance between peak and off-peak electricity demand as well as the demand for liquid fuels. Heat storage on a diurnal or even seasonal basis is a material factor in district heating.

INTERNATIONAL COLLABORATION

A wide range of activities is covered by the rubric of international co-operation – they are motivated by the common desire to share risks, information, costs and benefits to allow all participating economies to benefit to the greatest extent and ultimately to benefit the IEA economies as a whole. It offers particular advantages in technologies:

- where implementation is best served by an active programme of information sharing at the highest technical level, including task sharing projects;
- projects of high technical risk (but which are not necessarily excessively costly);
- in which the next step in meaningful R & D involves the design, development, construction and operation of a very costly experimental facility, which may be difficult or impossible for a single country to support;
- where collaboration would increase the efficiency and/or pace of R & D; and
- which have unique transboundary implications.

A most important form of information exchange is that of the sharing of experience. Task sharing and collaborative projects under the aegis of the IEA bring together the collective knowledge gained from parallel technical activities in Member countries, and thus can facilitate quicker exploitation of the research results than could be obtained on an individual country basis. In times of constrained budgets, but also as a positive and deliberate policy, governments should consider the advantages to be gained from participation in such collaborative projects.

Constrained budgets necessarily inhibit the unilateral pursuit of some research and development projects however desirable they may be thought to be. This situation is likely to continue in the face of increasing demands on limited RD & D financial resources as some of the technologies now in the earlier stages of development move toward progressively more expensive stages in the development cycle. The joint funding of projects by several countries can contribute significantly to the advancement of technological development under terms which will benefit all participants. In fusion energy for instance, the ability of even the largest economies to fund the next generation of new machines could be in doubt if other promising avenues of research are also to be

pursued. The advantages of joint planning, funding and operation of these significant capital projects are very great indeed. International co-operation of this sort is not without its complexities and problems, but these are primarily logistical and can be overcome by proper planning and good management. Governments should consider the potential for budgetary savings, accelerated development and shared risk of this approach.

NON-LABORATORY RESEARCH

Non-laboratory research (generally involving economic analysis of technical systems) can provide an economic and social complement to technical RD & D in two ways, by:

(a) improving understanding of an energy system per se, as well as its environmental impacts, and highlighting further technical and scientific R & D required; and

(b) identifying impediments to demonstration and application of previously successful technical R & D.

This can serve to underline the interdependence between energy, economic, and energy RD & D policies and provide a framework for further refinement of RD & D programmes.

CONCLUSIONS

This study has sought to examine the current energy RD & D situation in the IEA countries, and offers the following observations and conclusions.

GENERAL

— Energy RD & D supports, and is an important element in ensuring, the energy security of the IEA countries. It is important to the future well-being of their economies, both as a factor in maintaining economic growth and as a basis for transition to a less vulnerable energy supply/demand position.

— The size, diversity, resource base, and technical sophistication of an economy, its economic and social objectives, and its perceived national energy security position will be important factors in determining the mix of technologies appropriate for development by an individual country. It is thus both logical and appropriate to assume that the RD & D programme of each country will reflect its national energy circumstances, and its ability to fund and pursue certain projects and to implement the results of RD & D.

— Strong government commitment to maintaining overall energy RD & D investment is necessary to ensure continuity of direction and purpose, especially when cyclical short-term patterns of the energy market appear to provide little incentive for pursuing a given course. This commitment must be accompanied by a recognition in the technical community that individual technologies and projects must demonstrate steady progress towards the objectives for which they were established, and on-going relevance to the objectives of an evolutionary energy system.

— Significant energy RD & D initiatives have been undertaken since 1973-74, with mixed results. Some have resulted in technological advances, some have achieved commercial application, while others have demonstrated the inability of financial resources alone to assure technical or economic success.

— In general, the lead times for new energy technologies to move from the laboratory to the point of making even modest contributions to the market (a few per cent) have generally been measured in decades. Thus, while some R & D on new technologies may offer little promise for solving short-term energy problems (to 1990), RD & D decisions made by governments in the near term can have a significant effect and benefits in the medium to long term.

— While government RD & D may have a lesser direct role in the short term than RD & D conducted by industry, there is much which remains to be done. The role of governments is to ensure that the proper climate exists for short-term technology development, including the identification and implementation of measures to promote the introduction of new technologies and the improvement of existing ones.

— Governments, when considering energy policy are understandably concerned with time horizons conditioned by their current situations vis-à-vis the economic climate, oil price projections, and their various interpretations of the free market approach to rational

energy RD & D investments. Even energy security issues have been generally considered on a ten-year time frame. But much of energy RD & D is inherently long term. Its time horizons go well beyond the planning limits of even the most prosperous and far-sighted of commercial enterprises. This is currently true of both breeder technology and fusion energy research. It is also true of that accumulation of basic and applied knowledge which comes under the heading of "technology base", and of the development of synthetic fuel technologies and the widespread application of many renewable energies.

— The roles of government and industry in energy RD & D will reflect country-specific factors and the nature of the technology in question. Where a diversified technical and industrial infrastructure and a strong domestic market exist, there may be a basis for government reliance on the private sector for the development of a range of appropriate technologies. Conversely, a less diversified industry or less established technical infrastructure may require more applied government RD & D efforts to ensure the transfer of government-developed technology to the appropriate industrial sectors. The line between energy policy and general economic/industrial policy as well as considerations of energy security will also define these roles.

— Experience has shown that environmental concerns can impede or curtail the deployment of otherwise promising technologies. RD & D directed towards identifying and mitigating negative environmental impacts should be undertaken in conjunction with technology development as an integral and inseparable concern from the outset.

— International collaboration in the field of energy R & D already is important in certain technical areas and can make major contributions if properly planned and managed. Such collaboration can be particularly valuable when it:
  . increases efficiency of RD & D and resource application;
  . involves RD & D relating to technologies with transnational implications, particularly in the environmental, health and safety areas, such as acid rain and atmospheric carbon dioxide;
  . is based upon joint planning leading to the identification and definition of major new facility or experimental needs;
  . permits proceeding with expensive and/or high risk new undertakings which would be difficult or impossible for individual countries to do on their own; and
  . allows more rapid technical progress than otherwise possible.

— A clear distinction should be made between technologies which are technologically feasible but impeded by market resistance for economic or other reasons, and those where there is a need for more R & D; the appropriate measures (if any) will be quite different.

— Given the unpredictability of oil and gas supply interruptions, governments should ensure that technical measures capable of addressing short-term supply disturbances or price shocks have been taken. This might include work on:
  . more flexible and efficient end use;
  . fuel switching technologies, e.g. burner design;
  . reducing the lead time for the introduction of enhanced oil recovery and coal liquid mixtures; and
  . alternative indigenous resources.

— A strong continuing effort in fundamental energy-related scientific research is essential to the enhancement of the technology base which provides the foundation for successful applied effort in the future, and can avoid costly mistakes stemming from immature concepts.

— It is axiomatic that a well-directed RD & D programme, whatever its size and thrust, relies for its success on a well-trained cadre of expertise. Education and training thus remains an integral part of energy RD & D.

TECHNOLOGY SPECIFIC

The following technology specific conclusions have been drawn.

Energy-efficient technologies:

— offer a cost-effective way of influencing the supply/demand balance, and can reduce capital demands for additional energy-supply installations;

— can make an additional large contribution merely through the diffusion of existing technologies and the encouragement of consumer awareness;

— must stem from better understanding of end-use patterns and characteristics and of actual energy services needed and expected by consumers to devise the appropriate technological response;

— offer great potential for further energy savings, especially through measurements and control systems;

— would benefit from non-technical incentives as well as RD & D.

Oil and gas research requires:

— further development of basic exploration sciences, drilling technology, reservoir technology and enhanced oil recovery;

— design, maintenance and inspection of offshore structures, and associated distribution systems;

— further research into the identification and extraction of unconventional gas resources; and

— improved techniques for health, safety and environmental protection.

Coal research needs to be directed towards:

— enhancing the fundamental knowledge base resulting from years of relative neglect of basic coal science;

— understanding the phemonena of combustion to improve efficiency and address the formation of pollutants and the development of more advanced control technology;

— improving the economics of techniques to utilise coal more efficiently and cleanly;

— utilisation and/or disposal techniques for waste generated by pollution abatement measures; and

— advanced mining technology to ensure improved safety and efficiency of production.

Synthetic fuel developments should include:

— a further understanding of basic processes (e.g. reaction kinetics, catalysis);

— the development of durable components;

— the continuous pursuit of process technologies both of sufficient diversity to permit use of synthetic fuels products and to a scale adequate to permit decisions based upon commercial considerations;

— advanced cost estimation techniques to increase the reliability of projections for future investments;

— overcoming phase separation and engine corrosion with alcohol blended fuels;

— developing new gasifiers, reactors and underground gasification technology to enhance both the technology and the economics of coal conversion processes; and

— the development of hybrid systems, viz. coal and natural gas feedstocks and coal conversion/electricity production.

Conventional nuclear RD & D should focus upon:

— a comprehensive programme to resolve the remaining issues in nuclear waste management;

— continued improvement in reactor safety;

— ways to improve the next generation of thermal reactors, such as through improved fuel efficiency, improved plant reliability, enhanced inherent reactor safety, and facility standardization;

— an evaluation of the merits of developing advanced thermal reactors, including the merits and feasibility of developing "compact" simpler, more forgiving and shop-fabricated plants that might be attractive to certain operators; and

— for the HTGR, new designs and associated technology, and analysis of economic and market potential.

Breeder reactor RD & D programmes should:

— be directed towards the technology required for demonstrating commercial scale operation at reduced capital costs;

— address the problems and economics of reprocessing of highly radioactive spent fuel;

— explore the economic potential and feasibility of new reactor concepts, as well as innovative technical approaches; and

— continue to be oriented to close collaboration, pooling of resources, exchange of experience, and the development of common safety criteria at the international level.

Fusion energy research should address:

— the direction the "next step" should take as a logical progression from the present large tokamak machines;

— supporting technologies, such as superconducting magnet research, materials technology and tritium handling; and

— active opportunities for international collaboration to share costs, risks and benefits of investment in new large and costly experiments and supporting technology development.

Renewable energy sources:

— represent a very large potential. While some technologies have reached commercial maturity (solar heating, wind, biomass and geothermal), those whose contribution is expected to be largest (solar photovoltaics) are very long term;

— would benefit from government-supported RD & D to address critical cost reduction and reliability problems;

— need better data on locally available resources and an improved understanding of end-use patterns and their adaptability to renewable energy possibilities;

— may need some development of effective storage systems as part of a total system concept; and

— could make important contributions to regional development.

Cross-cutting technologies:

— electrical technologies should focus on improvement in the efficiency of conversion, transmission, load levelling and storage;

— improvements in electricity storage must include improved batteries, which will influence the further deployment of some renewable energy technologies and electric vehicle; and

— research and science policy and funding generally should reflect the importance of basic energy science, including materials science, reaction kinetics, geophysics relating to coal and oil and gas structures, and biogenetics.

APPENDIX H

The Washington Post 5-29-85

Kohl, Mitterrand Agree to Push Joint Research on Space Technology

But Leaders Fail to Resolve Split on Joining 'Star Wars'

By William Drozdiak
Washington Post Foreign Service

BONN, May 28—The leaders of France and West Germany agreed today on the need to establish a European research program for space and advanced technologies but failed to reconcile their conflict over participation in President Reagan's Strategic Defense Initiative.

Following more than three hours of talks at the lakeside resort town of Constance on the Swiss-German border, French President Francois Mitterrand admitted that he and Chancellor Helmut Kohl were still taking "different roads" in their approach toward joining the American space-based defense program.

At the Bonn economic summit earlier this month, Mitterrand declared that France would not accept a role in the so-called "Star Wars" research project as now conceived.

The French rejection startled the Kohl government, which remains inclined to accept a U.S. invitation to join SDI research but wants to formulate a joint European position.

France is urging its European partners to pool their resources in a common program known as "Eureka" to bolster civilian research in high technology sectors and prevent an accelerated "brain drain" of scientists and technicians toward the United States.

Britain and West Germany, after voicing some initial skepticism, have become increasingly interested in some kind of joint research program that would enhance Europe's prospects for future economic competition with Japan and the United States.

Kohl told reporters today that he shared Mitterrand's conviction that "it is vitally necessary for Europe to develop its own potential in high technology fields."

The chancellor said French and West German ministers in charge of research and technology would meet within two weeks to devise an agenda of possible European projects. A commission of scientists, economists and administrators from both countries would determine the feasibility of the proposals, Kohl said. He added that all European countries would be welcome to join the program but that Franco-German cooperation would serve as its basic foundation.

Kohl's comments indicated that his government might ultimately become involved in both the SDI and Eureka programs, even though senior policymakers in Bonn have warned that West Germany could not afford to support both.

A top-level delegation of government and industry specialists is scheduled to visit Washington soon to discuss a research role for West German firms.

Kohl has said in the past that his government feels the SDI project is "worthwhile and justified" but that he wants assurances that West Germany will be able to share fully in the research findings. He noted today that "a whole row of open questions" must be answered before the Bonn government could approve participation in SDI.

Mitterrand has repeatedly expressed doubts about U.S. willingness to accept European countries as equal partners in the SDI project. At the Bonn summit, he said his intuitions were confirmed during a private meeting with Reagan when he heard the U.S. president refer to Europeans as SDI "subcontractors."

Moreover, France is worried that its own nuclear deterrent force, now being modernized at huge expense, will be jeopardized if SDI leads to more sophisticated forms of antimissile defense or more advanced offensive weapons to overcome such a shield.

"The interests of our two countries cannot be identical in all circumstances," Mitterrand said after today's encounter with Kohl. "That is in the nature of things."

The chancellor also underscored the differing security interests behind the Bonn-Paris split over the SDI program. "France is a nuclear power and we are not. France is not part of NATO military structure, but our role in the front line of the defense of the western alliance is irreversible," Kohl said.

Both leaders emphasized the importance of close Franco-German ties as the essential basis for greater progress toward European unity. Kohl said he and Mitterrand hoped the next summit of European Community leaders in Milan at the end of June would take "important steps toward political union."

THE WALL STREET JOURNAL 5-23-85

West European Firms Seek Role in 'Star Wars,' Mindful of Widening Technology Gap With U.S.

By Richard L. Hudson P34
Staff Reporter of The Wall Street Journal

LONDON – In the end, a computer may decide whether Europe joins the U.S. "Star Wars" program.

It would be an ultrafast and cheap computer, one that almost never errs and can repair itself – in short, a device that Europeans would want to have themselves.

The technology behind such future machines is a potent lure for Europeans to join America's Strategic Defense Initiative, as Star Wars is formally known. Commercially attractive byproducts of the $26 billion research drive potentially include new communications devices, industrial robots, laser-cutters and space factories.

SDI will "have very substantial spin-offs," says William Gosling, technical director of Britain's Plessey Co., with an impact as big as the U.S. space program in the 1960s – "probably bigger," he asserts.

Mr. Gosling's own company – like scores of other big high-tech companies throughout Europe – doesn't want to be left out. Plessey already has been holding what Mr. Gosling calls informal discussions with potential U.S. partners about bidding jointly for SDI work. Concern about what the West German press calls the *Spin-Off-Effekt* has transformed the debate in Europe over whether to join the U.S. research effort.

Pressure to Join

"Six months ago, the focus of the debate was strategy," whether SDI would make or break world peace, says David Hobbs, a British official in the North Atlantic Assembly, an advisory body to the North Atlantic Treaty Organization. "Now, if you talk to European policy makers, the debate is: What about the technological spin-offs? Can we afford not to participate?"

Some nations have decided they can afford not to, fearing that SDI might accelerate the arms race and strain the Western alliance. Of the NATO partners (plus Japan and Australia) invited in March to join the research, the French and Norwegian governments have bowed out, and the Danish Parliament voted against participation.

West German officials have mixed views. Chancellor Helmut Kohl in a speech Monday called SDI both "an opportunity and risk" for NATO. But Britain is expected to take some role, and positive noises have been coming from Italian Prime Minister Bettino Craxi.

Western Europe fears becoming a technological backwater; in computing, consumer electronics, biotechnology, semiconductors, and other high-tech fields, it has been watching U.S. and Japanese advances leave it behind.

SDI could widen the gap, many politicians fear. "We believe the spin-offs will be such that we have to join," says a senior planning official in the West German government. Otherwise he sees "a danger of becoming a second-class industrial power."

The most immediate product of SDI research would be in conventional, nonnuclear weapons, European defense analysts say. For instance, among the devices being studied is a "rail-gun" – an electromagnetic track that can shoot projectiles at extremely high speeds. If European arms merchants don't have such technologies, defense analysts say, the currently lopsided arms trade between Europe and the U.S. may get even more out of kilter.

But the civilian spin-offs are what most intrigue European industrialists. For instance, SDI will need foolproof computers that can fix themselves, to analyze the mountains of missile-surveillance data collected by satellites.

> "SIX months ago the focus of debate was strategy. Now...the debate is: What about the technological spinoffs? Can we afford not to participate?"

Among other things, says Plessey's Mr. Gosling, that might require building a computer chip with built-in wiring to run tests on the rest of the chip; it would then steer the electronic impulses around any broken segments. Several manufacturers, including Plessey, are studying such chips, but SDI would give them the extra cash and urgency to speed development.

SDI entails advances in high-speed data communications, says Antonio Rodota, managing director of Italian state-controlled aerospace concern Selenia Spazio S.p.A. Improvements there, he says, would make civilian satellites, for mapping the earth and broadcasting, more economical, and "we can have a better chance to market" satellite services.

Advances in Coding

Moreover, he says, SDI will need more efficient, foolproof ways of encoding data communications, something almost as valuable to a big multinational bank as to the military.

However, critics argue that Europe doesn't need SDI to harvest these technological fruits. The French have proposed a purely civilian research drive called Eureka as a European alternative.

But the response has been lukewarm. Officials in Bonn and London express reluctance to spend any significant sums on Eureka. "I don't even know what it (Eureka) really means," sniffs one Foreign Ministry official in Bonn.

A more widely felt concern among European business leaders is that SDI participation, if bungled, could end up hurting them. Specifically, many executives worry that the SDI purchasers might treat Europe as a quaint specialty shop, picking over its high-tech wares, but excluding it from any serious joint research efforts. That's standard Pentagon practice in other programs, many European defense contractors complain. And the tight security surrounding SDI work will make it doubly difficult for European companies to share in SDI's technological advances.

Many West German and Italian companies are urging their governments to negotiate an early clear role for European industry. But the Reagan administration says so far that it wants to deal with its allies one at a time.

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THE WALL STREET JOURNAL

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5-23-85

While the debate goes on, many aerospace, computer and communications companies in Europe already have started pushing for SDI contracts, by sending scouts to Washington, talking with possible partners in the U.S. defense industry, and pumping their own governments for information and help.

Pentagon officials say they haven't begun contract talks with any non-U.S. companies, and a senior SDI official says he hasn't any preconceived ideas about what the Europeans might do. But the Pentagon has dropped some hints. On a recent trip to Bonn, Air Force Lt. Gen. James Abrahamson, the SDI chief, told of his interest in the tracking systems made by Dornier G.m.b.H.

Many European companies are readying their own ideas. Dornier, says Hans Hambos, a board member, is interested in several SDI research fields, including sensors, new materials and data handling. Selenia Spazio, says Mr. Rodota, is looking at radar, surveillance and data handling. And Plessey is interested in software and fault-free computer components.

The Washington Post 6-2-85

Bush to Tout 'Star Wars' Among Edgy Europeans

Mission Could Promote '88 Candidacy

P.A3 By David Hoffman
Washington Post Staff Writer

Vice President Bush is preparing to take on an assignment as diplomatic troubleshooter for President Reagan's controversial Strategic Defense Initiative, a research effort to build a high-technology shield against incoming Soviet nuclear missiles.

Bush has started briefings for a trip to Western Europe in which he will seek to ease allies' concerns about Reagan's missile defense program—often called "Star Wars"—and try to offset intensifying Soviet criticism of it.

The decision to send Bush reflects administration fears that the United States may have confused Western European leaders about the scope, cost and consequences of the $26 billion program.

"I think a lot of it is just being sure we're all reading from the same music," Bush said in an interview.

The trip also underscores the continuing Bush strategy of using the vice presidency as a platform from which to lay the groundwork for an expected 1988 presidential campaign. This would be his second major diplomatic effort of the year. Earlier, Bush visited famine-striken Africa and went to Moscow following the death of Soviet leader Konstantin Chernenko.

Although the timing of the European trip is uncertain, an advance team was there last week planning a visit that would include stops in Britain, France, West Germany, Belgium and the Netherlands.

Reagan's missile defense program was a major topic of discussion during last month's economic summit in Bonn, and there have been increasing signs of anxiety among Western European allies about their role in the program and its implications for their defense.

Unlike his high-profile European tour of 1982 to shore up support for the deployment of medium-range nuclear missiles, Bush said this time he expects to hold private meetings with Western European leaders. Among other things, he said he hopes to reassure them that "there is no intention" to "decouple" the U.S. nuclear deterrent from Europe if a missile defense system is perfected.

"Nobody's sitting off in a lab someplace saying, let's perfect this so we can live in a Fortress America," Bush said. "The principle is more noble than that. It is more moral than that. It leads inexorably down the line to the concept [of] why is it worth having nuclear weapons if you can perfect something to safely guard against them?"

Bush said he also hopes to allay allies' concerns about the technology and feasibility of the missile defense system.

On other topics:

- Bush said Soviet leader Mikhail Gorbachev continues to express a desire for progress in the Geneva arms talks, which have just resumed, but has shown "no firm evidence, no hard evidence of that."
- The vice president said tax reform could provide "a good shove" to Republicans in the direction of becoming the nation's majority party, but it's "too early to say that yet."

A potential Bush rival for the presidency, Rep. Jack Kemp (R-N.Y.), has been pushing for a lower individual top rate than the 35 percent proposed by Reagan, but Bush said he thinks Reagan proposed a "balanced package" that "preserves incentives" for some businesses as well as reducing individual rates. Bush was instrumental in restoring tax breaks for the oil and gas industry in the final Reagan plan.

- Bush lamented that the 1988 campaign "began last August in Dallas because there wasn't much suspense down there," and said that "with '88 looming over the horizon a little more closely, people try to hyper-analyze it, interpret things differently."

Bush said he is just "doing my job, the same as the last four years . . . . I think that still remains the best approach, whether it is for doing the job or political. Sometimes no politics is the best politics."

However, Bush has stepped up his political activity, having put together a new staff since his troubled reelection campaign last fall. A separate Bush political action committee, the Fund for America's Future, is in full swing, and Bush met privately with groups of Republican supporters in Phoenix and Baton Rouge, La., recently.

The Washington Times 6-5-85

NATO seeks solid front on 'star wars'

By Peter Almond
THE WASHINGTON TIMES FOREIGN SERVICE 7B

LONDON — NATO's 16 foreign ministers are due to arrive in Lisbon, Portugal, today for a meeting expected to be dominated by a need to prove to the Soviet Union that the alliance cannot be divided by differences on "star wars" research, and that the Soviets have nothing to gain by their stalling tactics in the Geneva arms talks.

The Soviets have said there can be no progress in the talks unless the United States agrees to abandon its Strategic Defense Initiative, called "star wars."

Western officials say this is a typical Soviet negotiating tactic and that the Soviets are making a mistake if they believe they can generate the same European public concern about "star wars" as they did over deployment of cruise and Pershing II missiles.

Privately, many are worried because the debate over "star wars" — unlike that over cruise and Pershing missiles — is primarily among governments. Norway, Denmark and France have told Washington they are not interested in joining the $26 billion SDI project. France, a member of the North Atlantic Council whose foreign minister will be at this week's meeting, has proposed a Europe-wide "Eureka" high-technology project as a civilian alternative.

Officially, SDI is not on the agenda at tomorrow's all-day closed session. It is considered too complex an issue for the short time foreign ministers have together and more appropriate for defense ministers.

But in reviewing the Geneva talks since they were restarted last January, ministers are expected to be forced to consider SDI to reach a joint response to the Soviets, who make no mention of their own "star wars" research. The Europeans also are expected to be interested in learning the exact U.S. stance on the SALT II arms-control agreement, which expires at the end of the year and whose limits are reportedly a matter of debate within the Reagan administration.

A senior British official said yesterday that he expected the allies would strongly back the American negotiating position taken last January, and the right of the United States to proceed with SDI research — though perhaps avoiding mention of European participation.

It was hoped, he said, that the ministers would agree to stress the importance of consultation, which Europeans complain has been lacking on the part of the United States in recent months.

European officials have been unhappy at U.S. determination to proceed with SDI — illustrated by Defense Secretary Caspar Weinberger's now dropped 60-day deadline for European involvement — and are expected to press U.S. Secretary of State George Shultz for more consultations to prevent the split from growing wider.

But Europeans are not expected to gang up on Mr. Shultz during the next few days, because they are badly divided on "star wars" themselves.

France consistently has opposed it; West Germany appears undecided whether to offend Washington or Paris. Chancellor Helmut Kohl has fluctuated from initial caution to becoming overwhelmingly in favor of SDI when President Reagan was about to visit Bonn. Then, after visiting French President Francois Mitterrand, he said he recognized there were two sides to the argument. Part of his problem is that his Free Democratic coalition partner, Foreign Minister Hans Dietrich Genscher, clearly favors Eureka over SDI.

Britain, America's strongest "star wars" supporter, has been troubled. Foreign Secretary Sir Geoffrey Howe urged more strategic thought to prevent a "Maginot Line of the 21st century." British sources said yesterday, however, that there would be little opportunity for Sir Geoffrey to examine such concerns with Mr. Shultz. The bilateral talks, he said, are more likely to be about the "shorter term issues" of how to manage the Geneva talks.

While the politicians argue, the Pentagon already has begun signing up European scientists and companies for SDI research.

At the Paris Air Show leading European aerospace and electronics groups were reported yesterday to be trying to coordinate their efforts to win maximum "star wars" orders. They were led by the French state-controlled Matra defense group, although the French government is strongly opposed to SDI participation.

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In Scotland, a leading university computing research group is set to get a Pentagon grant of $150,000, with more funds to follow, to produce a prototype optical computer, using beams of light up to 100,000 times faster than normal electron-driven computers.

Prof. Desmond Smith of Edinburgh's Heriot-Watt University, perhaps the world's leading expert on optical computing, reportedly had been trying for more than a year to get British government funds for the project, but was snapped up by the U.S. Navy recently to work with a California laboratory. He has given a verbal commitment to the Pentagon.

Because of U.S. secrecy laws and government restrictions on technology transfers, there are concerns in Britian

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that results of Prof. Smith's U.S.-funded research may stay in the United States and not return to Europe.

Concern about a possible European technological brain-drain is a major reason why Britain, Germany and other European countries are rallying in support of France's Eureka project. Because it would not directly involve military research, it would be less restrictive on scientists and companies and be more politically salable.

Eureka is not expected to be a major issue at Lisbon, although there are concerns that SDI and Eureka could be considered to be in competition for Europe's best scientific brains. Eureka, however, is likely to be discussed when European Economic Community foreign ministers meet in Stresa, Italy, this weekend.

Meanwhile, in Geneva, Switzerland, U.S. and Soviet space weapons negotiators met for nearly three hours yesterday. They refused to comment afterward because of a news blackout. It was their first meeting at the second round of talks, which began May 30, but their sixth encounter since arms negotiations resumed March 12 after an 18-month separation.

Separate negotiating groups on long-range nuclear weapons and on medium-range nuclear forces were expected to hold their weekly meetings tomorrow and Thursday.

In Moscow, Marshal Sergei Akhromeyev, armed forces chief of staff, reiterated the Soviet refusal to consider cuts in existing nuclear weapons unless Washington abandons SDI. Marshal Akhromeyev said the program is "incompatible" with the 1972 Anti-Ballistic Missile treaty and makes agreements at Geneva "inconceivable."

Moscow warns it would simply counter such a system with greater numbers of offensive missiles to penetrate a shield.

This article is based in part on wire service reports.

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Shultz Taking Soundings At NATO Conference

U.S. Watches Reaction on SDI, SALT II

A24 By John M. Goshko
Washington Post Staff Writer

ESTORIL, Portugal, June 5—NATO foreign ministers will begin their spring meeting Thursday with European members worried that the United States might endanger arms control by halting its compliance with SALT II limits on nuclear weapons and pushing ahead too aggressively with President Reagan's Strategic Defense Initiative.

Allied concern that these two issues could generate a hostile public backlash in Western Europe and further impede progress in the Geneva arms talks will be the principal issue confronting Secretary of State George P. Shultz at this session of the 16-nation North Atlantic Treaty Organization.

However, concern about the subject that last week threatened to dominate the meeting—Reagan's pending decision on whether the United States should continue abiding by provisions of the unratified SALT II agreement—appears to have abated considerably in the past two days.

A senior U.S. official said tonight that Reagan still has not decided what course he will follow and is waiting for Shultz's report on the sentiments expressed by the allies. The official said the first of these reports, focusing on Shultz's talks today with British Foreign Secretary Geoffrey Howe and West German Foreign Minister Hans-Dietrich Genscher, was sent to Washington tonight, and a more detailed report will follow Thursday.

The official said the Europeans had expressed understanding for the difficulties that Soviet violations of the SALT II provisions have caused for U.S. military policy. He added: "It is a matter of some delicacy. We don't want to ignore the Soviet violations. But we also don't want to damage the prospects for future negotiations" with the Soviet Union.

Despite the U.S. official's insistence that Reagan is still making up his mind, sources within various European delegations said they believe Washington now is on notice that a blanket U.S. refusal to respect SALT II limits will have severely divisive effects on the alliance and give the Soviet Union a propaganda advantage with which to reignite sentiment against NATO's nuclear strategy.

As a result, the sources continued, the allies now seem relatively confident that Shultz will hint strongly at a compromise acceptable to European opinion. Specifically, they said, the Europeans expect Reagan to choose the so-called "gray-area approach" that will allow the United States to contend that it is in compliance with the spirit if not the strict letter of SALT II provisions.

After a meeting Monday of the National Security Council, U.S. sources said the United States was unlikely to dismantle a nuclear-armed Poseidon submarine when the new Trident submarine Alaska enters service. Full compliance with the SALT agreements would require dismantling of the Poseidon's firing tubes within six months.

However, Shultz is understood to have argued that the United States could comply with the spirit of the agreements by removing the Poseidon's nuclear missiles and putting it in indefinite drydock.

The Europeans say they now expect that Shultz will make clear in his secret talks here that Reagan's decision, which is to be announced Monday, will follow the general outlines of that plan.

The other issue with which Shultz will have to contend is European concern about the Strategic Defense Initiative, a research effort to build a high-technology shield against Soviet nuclear missiles.

Reagan's claims that such a program could make nuclear war obsolete have made almost no headway against European fears that it will mark the start of a new arms race in outer space, lessen U.S. willingness to defend Western Europe from nuclear attack and give the Soviets an excuse for refusing to negotiate in Geneva on reduction of nuclear missiles.

On the surface, most of the NATO allies have gone along with the SDI to the extent of endorsing "research" into such defenses. But continued distrust in Western European public opinion has forced many allied governments to seek to deemphasize the subject's prominence and get it out of the realm of constant public discussion.